8.0 Troubleshooting

Caution: Repairs and calibration should be performed by qualified service personnel.

8.1 Troubleshooting Guide

When an error occurs during measurement, a message appears on the fourth line of the information within the LCD window. Explanations of these errors are listed in the following table.

Symptom	Check
Blood pressure unit will not turn on	Is battery light green (if not using A/C power)? If not, plug unit in for battery charging. Is the power cord properly inserted into a working electrical outlet? Is it completely plugged into A/C power outlet on rear of unit? Have a qualified service personnel verify the "slow blow fuses."
Blood pressure unit will not display	Is the "DISPLAY" switch on the rear panel in the "ON" position? Is the power cord properly inserted into an electrical outlet? (For measurements on battery power, check the battery indicator on the front of the unit is illuminated green.)
Cuff will not inflate	Are all cuff and cuff hose fittings secure and without leaks? Are error codes displayed on the LCD screen on the front of the unit? If so, call COLIN Technical Services at 800-829-8100. If the displayed cuff pressure is increasing rapidly but the cuff is still not inflating, check to see if the cuff hose is crimped or bent.
Printer will not print	Is the "PRINTER" switch on the rear of the unit in the "ON" position? Is the paper loaded properly? Are you using COLIN brand thermal paper?
Blood pressure measurement results are questionable	Are you using the correct size cuff and proper cuff wrapping technique? See cuff placement instructions in this manual.
Temperature measurement results are questionable	If measurements are still questionable, refer unit to Biomedical Engineering or COLIN Technical Services for a calibration verification test.

Note: Blood pressure measurements on patients with severe arrhythmia may be difficult using this instrument.

8.2 Troubleshooting – Possible Causes and Remedies

While monitoring blood pressure, problems may occur causing difficulty with accuracy, monitor performance and patient comfort.

The following information may be used to help troubleshoot some of these problems:

Patient comfort-

Patient comfort in most cases is compromised by not using the appropriate cuff for the patient, or using proper placement techniques. *Verify the cuff size, placement of the cuff over the brachial artery, placement of the cuff above 1.5 inches above the elbow, as well as how tight the cuff was wrapped.*

Patient movement or arrythmia may also cause the unit to take longer and cause additional discomfort for the patient. *Observe the patient to see if motion may have affected the monitor, or if the monitor has a printer, look at the printout to see if the motion artifact mark appeared (#).*

Monitor settings may also influence the comfort of the patient. Make sure the appropriate inflation settings have been used and that the monitor is in the appropriate adult or neonatal mode. A small leak in the cuff or air tube may also cause the unit to take longer to obtain a measurement. *Verify the inflation pressure settings of the monitor. Check the integrity of the cuff and hose by wrapping the cuff around a cylindrical object and placing the monitor into the service mode and running the calibration test, if the pressure does not remain at constant pressure, replace a component at a time (cuff, hose, monitor) until the leak has been ceased.*

Accuracy-

The accuracy of the monitor can only be judged by verifying the patient's blood pressure against another source. *This verification can only be done if second measurement occurs immediately after the first measurement has been taken. You can also verify the measurement by first validating the calibration of the monitors transducer, verify no leaks are present in the monitor, cuff, or hose, then place a stethoscope under the cuff and let a qualified person take an auscultatory measurement at the same time as the monitor. This auscultatory measurement will use the pressure from the monitor's display and the automatic deflation of the monitor as well. Remember an auscultatory measurement averages a 5-7 mmHg lower systolic and 5-7mmHg higher diastolic value than an oscillometric measurement.*

Monitor failures-

Colin monitors offer the user a source of displayed information to help them with monitor failures. These messages include advisory, caution, and error codes. The following information may be displayed.

Messages-

- Battery Low and Charge Battery- These messages alert the user that the monitor is operating on battery power and must be plugged into an AC source for continued operation. *If one of these messages appear and the monitor is connected to an AC source, verify the power cord, fuses, and if AC is even at the plug itself.*

- Blank Mode- This message alerts the user that the display switch on the back of the monitor is in the OFF position.

- E01 and E02 RAM/ROM Failure- These messages alert the user to failure of the self test of the unit. *If one of these messages appear, restart the unit and if the message reappears the unit must be serviced by the appropriate personnel.*

- E03 Cuff Disconnect- Is displayed when the monitor did not inflate to a pressure above 10 mmHg within 10 seconds. *Verify cuff and hose for extreme air leakage. Also verify that the connections of the above to the monitor or cuff are made and tight. If the pump did not even start, the monitor requires repair.*

- C11 Check Cuff- Is displayed when the monitor did not inflate to the inflation pressure setting within 30 seconds. *Verify for a small leak in the monitor, cuff, hose, or connection.*

- C12 Check Cuff- The cuff deflated to a pressure of 10 mmHg, and no measurement was z *that a neonatal cuff is not being used in the adult mode.*

8.3 Error Codes — Blood Pressure Monitor

Error Code	Displayed Message	Description	Probable Cause
E01	"E01 Internal Error"	RAM failure	
E02	"E02 Internal Error"	ROM failure	
E03	"E03 Cuff Disconnect"	The pressure was less than 10 mmHg more than 10 seconds after starting the pump.	Check connection between the unit and air hose, and cuff.
E21	"E21 Internal Error"		Shorting block on back of unit.
C11	"C11 Check Cuff"	The cuff pressure did not reach the specified value within 30 seconds (10 seconds for neonates) after starting measurement.	Check the cuff and hose connector for air leaks.
C12	"C12 Check Cuff"	The pressure dropped to 10 mmHg but the measurement was not completed.	Check the cuff for normal position and patient motion.
C13	"C13 Motion Artifact"	The air was not discharged within 15 seconds because of body movement.	Check body movement or arrhythmic patient.
C14	"C14 Reinflation"	Apply pressure again.	Check insufficient pressure because of high blood pressure.
C15	"C15 Irregular Pulse"	Abnormal oscillometric waveform.	Check body movement or arrhythmic patient.
C16	"C16 Weak Pulse"	Impossible to measure due to noise by arrythmia or body movement.	See C15
C17	"C17 Time-Out"	Measurement took more than 90 seconds.	Check for cause of obstructed air discharge, e.g., movement of patient or bent or crimped hose.
C18	"C18 Time-Out"	More than 100 pulses were detected during measurement.	See C17
C19	"C19 Pressure Error"	Cuff pressure rose above 325 mmHg (150 mmHg for neonates) during measurement.	Check for folded patient arm or bent hose.
C20	"C20 Low Pulse Error"	Pulse was too low to measure.	Check proper attachment of cuff.

8.4 Problems with the unit – Cause & Solution

As problems occur with the operation of the unit, you can use the following possible solutions to aid in the troubleshooting of the problem. You may be required to utilize this information in conjunction with the service calibration procedures to accurately troubleshoot the source of the problem.

Cannot turn ON the power to the unit.	
CAUSE	SOLUTION
Cord is unplugged or loose	Check the power input cord connections and or verify with a known good power cord.
Fuses on back panel defective	Verify that the fuses are not defective and if so, please replace the defective fuses with the appropriate sizes as marked on the back panel of the monitor. (Slow blow type only)
Sheet Switch Defective	Verify that the ON and OFF buttons are not stuck, and that you can feel the depression of the dome as each button is pressed.
Transformer may be defective	Verify the voltages at the output of the transformer
Power supply defective	Verify the output voltages of the power supply, also check pin 6 to pin 8 of the power supply as the front switch ON is de pressed the signal should be pulled low.
Main board defective	If pin 6 is not pulled low as the ON switch is depressed and pin 31 of CN1 is pulled low. Then replace the main board.

The unit overheats	
CAUSE	SOLUTION
The unit is too close to its surroundings	Remove objects that are too close to the bottom of the unit.
The battery is defective	Replace defective battery. If battery draws too much current overheating may occur.

The unit will not operate on battery power.	
CAUSE	SOLUTION
Defective battery connection	Remove and battery door and clean and check connections.
The battery is defective	Replace defective battery.
Blown F1 fuse on Power supply	Replace defective 3A fuse.

The unit seems to turn ON but the display is blank or fully lit.	
CAUSE	SOLUTION
Display switch is OFF	Verify the display switch on the rear case is on.
LCD ribbon cable dislodged	Verify the ribbon cable is correctly attached.
VR1 on main board changed	Verify VR1 on the main board is appropriately set.
LCD defective	Rework or Replace defective LCD. If the NEO LED lights, but the unit will not function, this indicates a defective LCD.
Main Board defective	Replace defective main board.
Display board may be defective	Replace Display board
EPROM defective	If the unit's software was just upgraded, the EPROMs may be inserted incorrectly or is defective.

Unit will not turn off	
CAUSE	SOLUTION
Sheet switch failure	Verify that as the OFF switch is depressed a bubble or depression can be felt. Replace sheet switch if no depression is found.
Power supply is defective	If the OFF switch is depressed, pin 6 should be pulled high. If it is replace RY1 or the power supply.
Main board is defective	If pin 6 was no pulled high then replace the defective main board.

No sound	
CAUSE	SOLUTION
Alarm Mute Active	Verify in the configuration screen that Volume is ON
Speaker wire disconnected	Verify connection of Speaker wire
Speaker is defective	Verify if power is passing through to speaker, if so replace defective speaker

Front panel switches don't work or LEDs will not light

CAUSE	SOLUTION
Sheet switch is defective Or not connected	Verify the ribbon connector from the switch to the display board is connected. If you cannot feel the depression of the switch, replace the sheet switch.
Main Board Failure	Replace Main board
Display Board is defective	Replace display board or LED is found to have missing segments or do not light.

Time clock is drifting or cannot set time

CAUSE	SOLUTION
Time is not set	Reset time selection and try again
Clock Battery defective	Replace clock battery, verify that when unit is ON, 2.4 Vdc charger voltage is present.
Clock IC defective	Replace U2 clock IC
Main board is defective	Replace defective main board.

Unreliable readings (Inaccurate NIBP)

CAUSE	SOLUTION
Rapid cuff deflation	Check for leaks in hose and cuff.
Cuff Placement and Positioning	Verify appropriate cuff placement and positioning
Cuff not at Heart Level	Verify and place cuff at patient's heart level
Patient movement	Calibrate TBP measurement by initiating a cuff calibration.
Position Indicators	Check and adjust placement of sensor
Severe patient arrhythmia	Verify with a manual cuff measurement
Vibrations including shivering	Look for patient movement, take appropriate measures

Unreliable readings (Inaccurate NIBP) Continued	
CAUSE	SOLUTION
Unstable blood pressure	Verify patient for reciprocal pulsations or respiratory alterations.
Patient Physiology	Patient's pulse pressure may not be adequate for monitor to allow TBP measurements. Continue with oscillometric measurements.
Calibration (NIBP)	Check the calibration of the NIBP transducer
Deflation Speed	Check for internal leaks and deflation speed.

Cuff does not inflate	
CAUSE	SOLUTION
Cuff hose may have a faulty connection	Check all connections and hoses for damage
Cuff may have a leak	Check connections and replace is faulty
Sheet switch is defective	Verify depression of Start/Stop button. Replace defective sheet switch.
Power supply failure	Verify output voltages, repair or replace power supply.
Pump failure	Verify that when 12 Vdc is applied to pump, pump starts
Main Board failure	Verify that when Start/Stop switch is depressed, 12 Vdc is applied between pins 1 and 2 of CN3. Replace defective Main board.

Overall Battery Life is suspect	
CAUSE	SOLUTION
Battery charge rate low	Verify charge voltage to the battery is from 14.2-14.8 Vdc.
The battery is defective	Replace defective battery. You can test the battery by completing the following steps: 1. Test the battery with a battery analyzer. 2. Verify that once charged the battery voltage remains above 12 Volts and does not continue to fall. 3. Place the unit into the Safety timer test, run the test three times, each time verify the battery voltage stays above 12 volts.

Overall Battery Life is suspect	
CAUSE	SOLUTION
Blown F1 fuse on Power supply	Replace defective 3A fuse.
Low/Empty Indicator failure	Connect a DC power supply to the unit in place of the battery. Slowly decrease the voltage of the power supply from 14.0 volts until the "Battery Low" indicator is shown. The voltage should be 11.8 +/- .1 volts. The "Battery Empty" indicator will appear at 11.2 +/- .1 volts. Replace main board or rework circuit as required.
Use/Charging Style	If the unit is not connected to AC the required time throughout the day compared to the time in use, the battery may prematurely fail due to inadequate charging. Replace battery and change charging circuit as described in procedure
Power Source	Verify appropriate AC power from plug, to cord, to fuses, to transformer, to power supply.

8.5 Repair Notes

While repairs are in progress it is always important not only to verify operation after the repair, but to also check for the following, if you are to familiar with one of the below mentioned upgrades or kits, call Colin's Technical Service at 800-829-6427:

Front Case- When replacing the front case make sure to check the following:

1. Chassis is not bent or damaged.
2. Nylon washers between LCD and front case are present.
3. No nicks or holes are in LCD interface cable.
4. Grounding strap of sheet switch is connected appropriately.

Rear Case- When replacing the rear case make sure to check the following:

1. Has the main AC ON/OFF switch been removed with the upgrade?
2. Is the metal C-clamp for the pole holder bracket straight and not opened beyond its normal C shape. Use of a ball peen hammer or vise will help to return bracket to its normal shape.
3. Is the rubber pole holder still in place on the plastic pole mount?
4. Is the grounding bracket placed onto the new rear case (bracket is located next to the battery housing and connects with a bronze 3 x 4 to the rear case).
5. Has the unit been upgraded with the top left and right reinforcement bracket kits, they are placed onto the chassis and extend to protect the top corners of the rear case?
6. Has the unit's pole holder been upgraded with the metal sliding bracket and the white pole sliders ears been removed.
7. Verify the battery connector is again attached as the rear case is placed back onto the unit.
8. Verify the battery felt is not between the rear and front case joint.

Battery- When the battery is replaced always verify the following:

1. Is the battery charging voltage appropriate for the type of use the department will use it for? 14.0–14.4 if battery back-up only, 14.6–14.8 if used only on battery power.
2. Is the battery low and empty indicators correct? (see troubleshooting)

Main Board- When the main board is removed or replaced, verify the following:

1. Is the appropriate software on the board?
2. Are the dip switches set appropriately?
3. Is the A-Tube kinked behind the power supply cable or between the board and chassis?
4. Is the printer cable connected, if applicable?

9.0 Illustrated Parts Listing

9.1 Parts Listing: 8800

PC BOARD

ID #	Part #	Description
1	0330187A	Main Board 8800P
1A	0330244A	Main Board 8800P (Smart Features)
1B	0330188A	Main Board 8800C
1C	0330245A	Main Board 8800C (Smart Features)
1D	0330207A	Main Board 8800MSP (no Neonate)
1E	0330206A	Main Board 8800MS (no Neonate)
2	0310050A	Display Board 8800C/P
2A	0310061A	Display Board 8800C/P (amber MEAN)
2B	0310048A	Display Board 8800MS/MSP
2C	0310063A	Display Board 8800MS/MSP (sys Hi/Lo alarm)
3	X8150030B	Printer Board 8800P,MSP

FRONT PANEL

Front Case Kits are as follows:

Front Case C (8800C units)	Basic unit with no printer
Front Case P (8800P units)	Basic unit with printer
Front Case MS (8800MS or T)	Basic unit, no printer, with tympanic
Front Case MSP (8800MSP or TP)	Basic unit, w/printer, w/tympanic
Front Case SC (8800SC units)	Smart unit (SYS alarm LEDs), no printer
Front Case SP (8800SP units)	Smart unit (SYS alarm LEDs), w/printer
Front Case SMS (8800SMS units)	Smart unit (SYS alarm LEDs), no printer, with tympanic
Front Case SMSP (8800SMSP)	Smart unit (SYS alarm LEDs), w/printer, with tympanic

ID #	Part #	Description
4	3200115C	Front Case without Labels
5	XC2250167A	Sheet Switch 8800P/MSP/TP
5A	XC2200250B	Sheet Switch 8800P/MSP (sys. Hi/Lo alarm)
5B	XC2250168A	Sheet Switch 8800C/MS/T
5C	XC2200251B	Sheet Switch 8800C/MS (sys. Hi/Lo alarm)
6	2200126B	Front Panel 8800C/P
6A	2200181A	Front Panel 8800SC/SP (amber MEAN)
6B	2200171A	Front Panel 8800MS/MSP
7	XC2120577A	Packing Plate
8	3200119B	Paper Cutter Assembly 8800P
9	3200117A	Printer Cover Plate
10	XC7730003A	Rubber Leg, (foot, rubber,8800)
11	XC2120537B	Stopper, L Shape Front Case
12	X4100191A	Hexagon Nut Shaft
13	XC5620003B	Backlit LCD Display

REAR PANEL

Rear Case Kits are as follows:

Rear Case C/TC (8800C or 8800TC)	Basic unit, no printer, no ON/OFF switch
Rear Case C PS (8800C or 8800TC)	Basic unit, no printer, w/ON/OFF switch
Rear Case P/TP (8800P/TP/MSP)	Basic unit, w/printer, no ON/OFF switch
Rear Case P PS (8800P/TP/MSP)	Basic unit, w/printer, w/ON/OFF switch
Rear Case MS (8800T wo/neo switch)	Basic unit, no printer, wo/neo switch
Rear Case MSP (8800TP wo/neo switch)	Basic unit, w/printer, wo/neo switch
Rear Case SC (8800SC/SMS)	Smart unit (SYS alarm LEDs), no printer
Rear Case SP (8800SP/SMSP)	Smart unit (SYS alarm LEDs), w/printer

ID #	Part #	Description
14	3200116D	Rear Case W/O Labels
15	XC2170101C	Slide Bracket
16	4230007B	Knob Slide Base
17	3200122B	Knob w/Shaft
18	X2120538A	Stopper, Rear Case
19	XC2570003B	Sponge Handle
20	XC3200118B	Pole Holder w/Rubber Holder Kit
21	XC2360008B	Rubber Holder
22A	2250050C	Rear Sheet Label 8800P/MSP
22B	2250243A	Rear Sheet Label 8800P/SMSP (with Print Mode)
22C	2250061B	Rear Sheet Label 8800C/MS
22D	2250171B	Rear Sheet Label 8800MSP (no Neonate)
22E	2250172B	Rear Sheet Label 8800MS (no Neonate)
23	XC7240008A	Battery 12 Volt, 2.3 Ah
24	4100185A	Screw for Battery Cover
25	2100529B	Battery Cover
	XBTCVR	Battery Cover w/screws kit

INSIDE

ID#	Part #	Description
27	XC0140016C	Main Chassis
28	6800031A	Power Supply Board-25% Exchange Item
29	6700054A	Power Transformer(115v)
29A	6700055A	Power Transformer(220v)
30	XC7270002A	AC Inlet
31	XC7210031A	Fuse Holder & Cap
33	XC7220002A	Fuse (1 Amp Slow Blow)
35	4100281A	Grounding Terminal
36	4100183B	Support Cord Stop
37	2160073A	Cord Stopper
38	0250046A	Luer Lock for Chassis(M)

ID#	Part #	Description
39	XC2110394C	Sub Chassis
40	6820001A	Printer 8800,BX-5
41	X2120531B	Printer Stand
42	X2120534C	Photo Interrupter Bracket
43	0780002A	Photo Interrupter
44	X4240012A	Roller Guide
45	XC6140390A	Overpressure Switch
46	3210021B	Paper Box
47	X3210022A	Paper Box Base
48	XC2110266B	P, Plate Paper Guide
49	0200023A	Pump w/Pump Nut
51	XC2120861A	Rt. Reinforcement Bracket
52	X2110393B	Pump Bracket
53	0200033A	Bleed Valve
54	0250029A	Air Manifold
54A	X0250048A	Air Manifold (Smart Inflation)
55	3260003B	L-Tube
56	XC75310170	Air-Tube A
57	XC75301170	Air-Tube B
58	XC75310040	Air-Tube C
59	7540005A	Clamp
60	X3260013A	L-Tube D
	XC2120861A	Rt. Reinforcement Bracket
	XC2120862A	Lt. Reinforcement Bracket
	XC2120860A	Slider Reinforcement Bracket
	X7540024A	Valve, Solenoid

TYMPANIC HOUSING PARTS

ID#	Part #	Description
	X3200424A	Left Hinge (Blue)
	X3200423A	Right Hinge (Blue)
6	3200422A	Door, Probe Cover Holder (Clear)
4	3200464A	Honeycomb, Probe Cover Holder
	2270059A	Spacer Honeycomb, Lg. (White)
	3270012A	Spacer Honeycomb, Sm. (Blue)
	2270060A	Spacer Honeycomb, Sm. (White)
	2570010A	Felt Honeycomb (Black)
13	1600206A	Label, Rear Sheet 8000MS (w/interface)
13	1600205A	Label, Rear Sheet 8000G (no interface)

9.2 Accessory Parts List: 8800

COLIN MEDICAL INSTRUMENTS hours of operation are 8 a.m. to 6 p.m. (Central Standard Time), Monday through Friday. Call us for pricing or additional information at 800-829-NIBP (6427).

Description	Order #
Accessories	
Wall Mount	C0610020A
Operation Manual 8800 Series	C1730020A
Service Manual	C1730016B
Inservice Videotape	Call
3.5m gray adult hose	0450010B
3.5m green neonatal hose	0450012B
Printer paper, box (5 rolls)	C1780009A
NIBP calibration test kit	C0690003A
Fetal monitor interface cable	C7110001A
Dust cover	XC1810012A

Description	#/Pkg	Order #
Adapters: 1-Tube to 1 Tube		
Hewlett Packard	25	C0430021A
Physio-Control	25	C0430023A
Spacelabs	25	C0430025A
Marquette (new)	25	C0430027A
Marquette & Propaq (old)	25	C0430029A
1-Tube to 2-Tube Reusable/Disposable Cuffs		
Colin, Datascope N.A.D. (new style-Critikon)	10	C0430022A
Colin, Datascope N.A.D. (old style-Critikon)	10	C0430024A
Dinamap, Spacelabs	2 sets/10 sets	C0430030A
Hose Connectors: 1-Tube to 2-Tube Neonatal		
Colin, Datascope N.A.D.	10	C0430033A
Colin, Datascope N.A.D (without fittings)	10	C0430034A
Reusable Cuff Covers		
Infant	1	C0430041A
Child/small adult	1	C0430042A
Adult	1	C0430043A
Large Adult	1	C0430044A
Thigh	1	C0430045A

Description	Order #	Order #
Reusable Blood Pressure Cuffs		
	1-tube	2-tube
Infant	C0430001A	C0430002A
Child/Sm. adult	C0430003A	C0430004A
Adult	C0430007A	C0430008A
Large adult	C0430009A	C0430010A
Thigh	C0430011A	C0430012A
Cuff Assortment Packs		
	1-tube	2-tube
Reuse. Assort. Pk.	C0430091A	C0430092A
Reuse. Adult Pk.	C0430093A	C0430094A
Reuse. Child Pk.	C0430095A	C0430096A
Disp. Assort. Pk.	C0400081A	C0400082A
Disposable Cuffs		
	1-tube	2-tube
Large adult/thigh	C0400011A	C0400012A
Adult	C0400013A	C0400014A
Pediatric	C0400015A	C0400016A
Neonate (#4)	C0400017A	C0400018A
Small pediatric	C0400019A	C0400020A
Neonatal Cuffs		
	1-tube	2-tube
#1	C0400001A	C0400002A
#2	C0400003A	C0400004A
#3	C0400005A	C0400006A
#4	C0400007A	C0400008A
#5	C0400009A	C0400010A
Reusable Cuff Bladders		
	1-tube	2-tube
Infant	C0430053A	C0430054A
Child/small adult	C0430055A	C0430056A
Adult	C0430057A	C0430058A
Large Adult	C0430059A	C0430060A
Thigh	C0430061A	C0430062A

9.3 Parts List: 8000MS, 8000IR, 8000N

ID #	Part #	Description
1	3200417A	Base Case
2	3200418A	Right Case
3	3200419A	Left Case
4	3200419A	Probe Cover Case
5	3200420A	IR Detector Plate
6	3200422A	Door
7	3200423A	Door Hinge Right
8	3200424A	Door Hinge Left
9	3200425A	Genius Latch
10	3200426A	Latch Guide
11	3200427A	Latch Spring
12	7700017A	Magnet
13	1600148A	Rear Label
14	2150347A	Serial Number Plate
15	7730003A	Rubber Foot
16	6441030A	IL-2S
17	0450027A	Curl Tether
18	7100069A	Ground Wire 1
19	7100070A	Ground Wire 2
20	7100071A	Ground Wire 3
21	7140060A	LED, 8800IR
22	0370065A	Main PC Board
23	0370069A	OPIC Unit
24		Caution Label

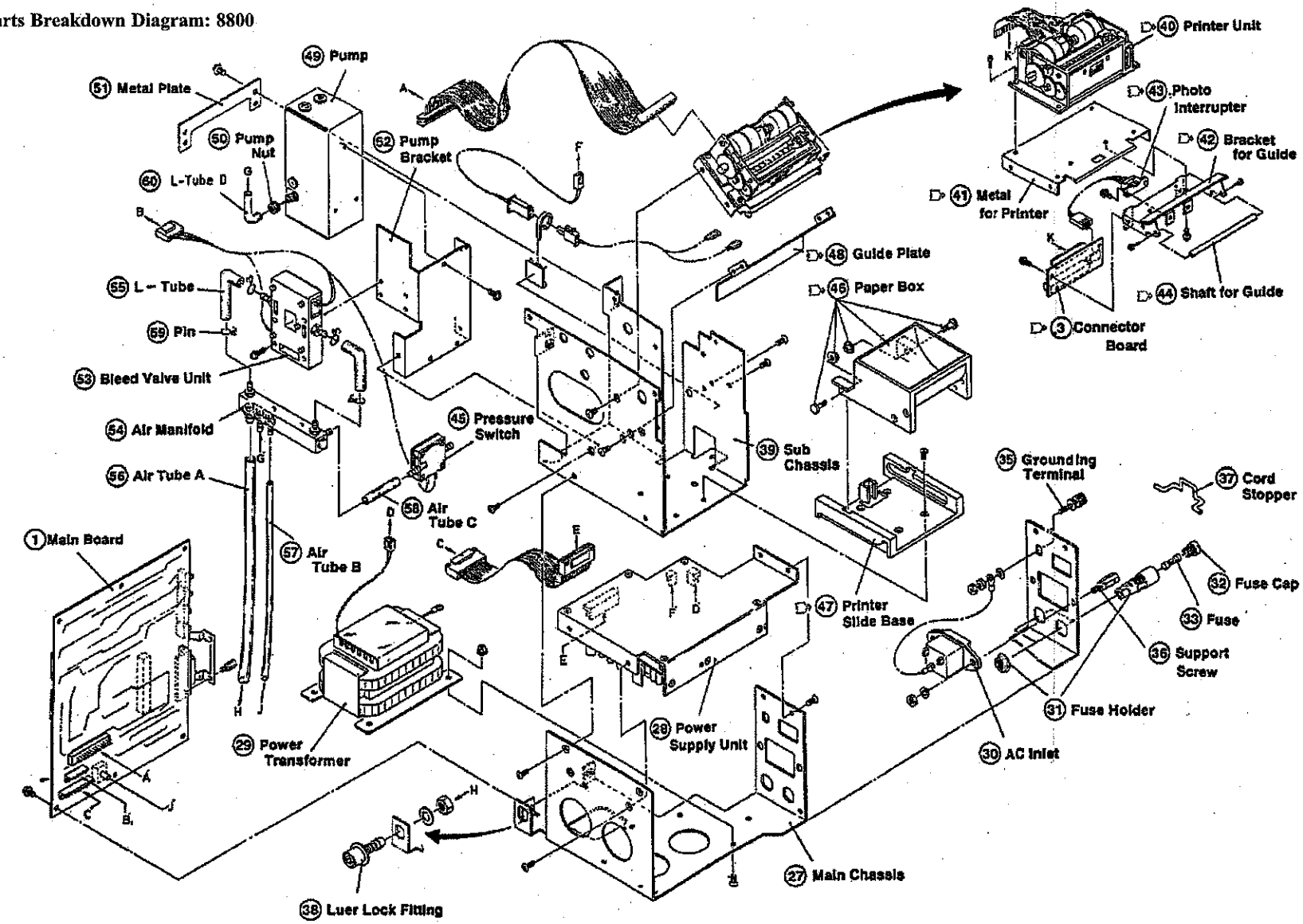
9.4 Parts List: FILAC

ID #	Part #	Description
1	7774-005909	Printed Circuit Board Assembly
2	7774-101971	(2) "AA" Battery
3	7774-105717	Normal/Direct Mode Switch Assembly
4	7774-701077	Touch Panel
13	7774-178003	Mylar Overlabel
14	7774-400233	(2) No. 6 Plain Washer
15	7774-303213	(3) No. 4 - 10 x 1/4" Self Tap Screw
16	7774-303783	(2) No. 4 - 10 x 1 1/2" Self Tap Screw
17	7774-304286	(2) Flathead Tubular Rivet
18	7774-105725	Battery Clip Assembly
20	7774-304773	(2) Stainless Steel Dowel Pin
23	7774-304807	(2) No. 2 - 32 x 5/32" Self Tap Screw
24	7774-304815	(3) No. 3 - 28 x 5/16" Self Tap Screw
25	7774-304823	(2) No. 4 - 24 x 7/32" Self Tap Screw
26	7774-401793	Neck Strap
28	7774-807163	Instruction/Serial Number Label
29	7774-307099	Switch Actuator
30	7774-309756	Case Top
31	7774-309764	Case Bottom
32	7774-309889	Case Bolt
33	7774-106053	Battery Door Assembly
34	7774-309905	Fascia
35	7774-309913	Right Battery Compartment Mount
36	7774-309921	Left Battery Compartment Mount
37	7774-309939	Probe Box Retainer
38	7774-310259	F-2000 Labels
38A	*	Dip Switch Label
38B	*	Battery Label
38C	*	Copyright Label
38D	*	Direct/Normal Label
39	7774-106079	Case Top with Neck Strap Assembly (items 14, 17, 26 & 30)

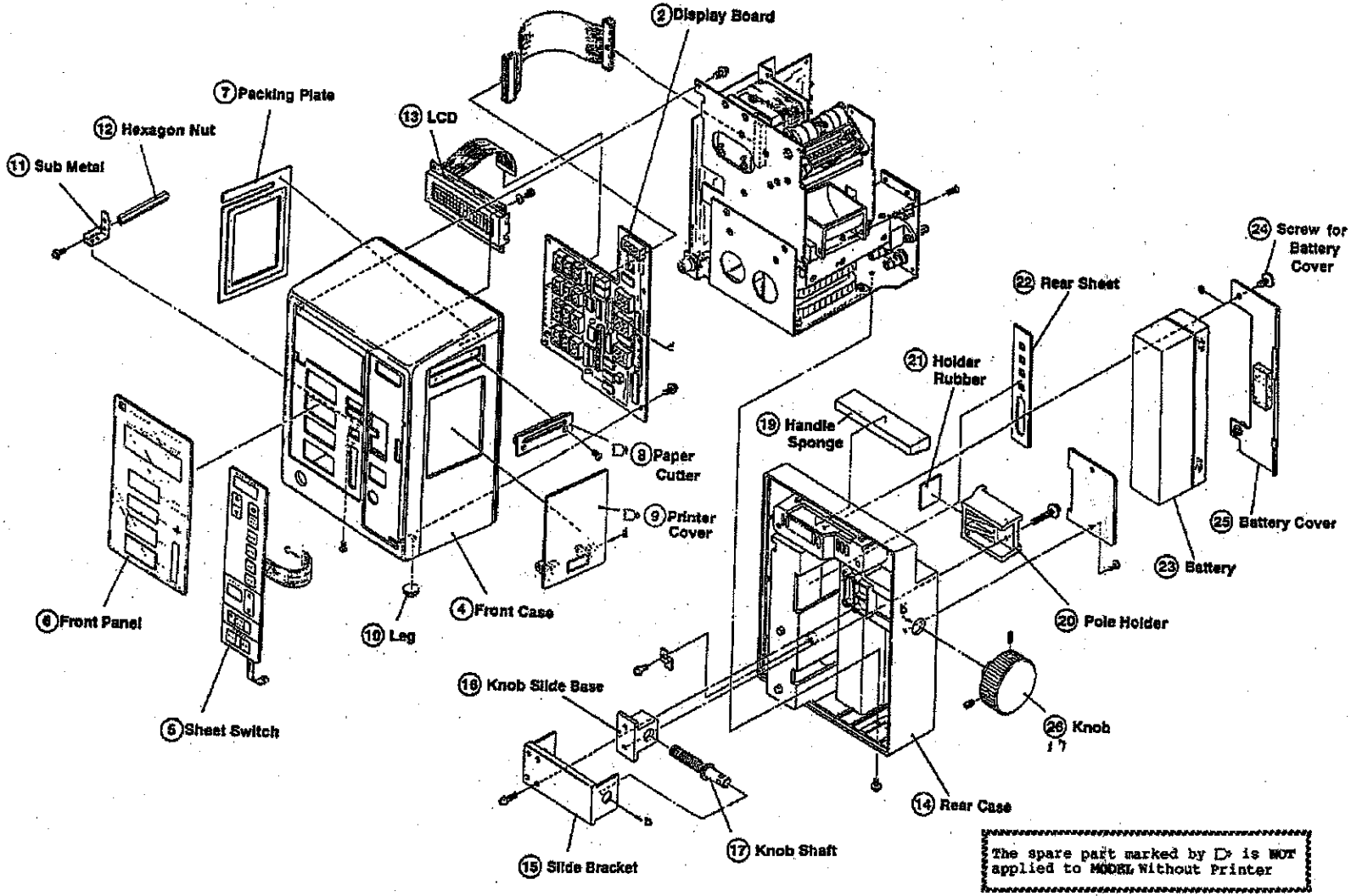
Part of Item 38

NOTE: Parts available through Kendall.

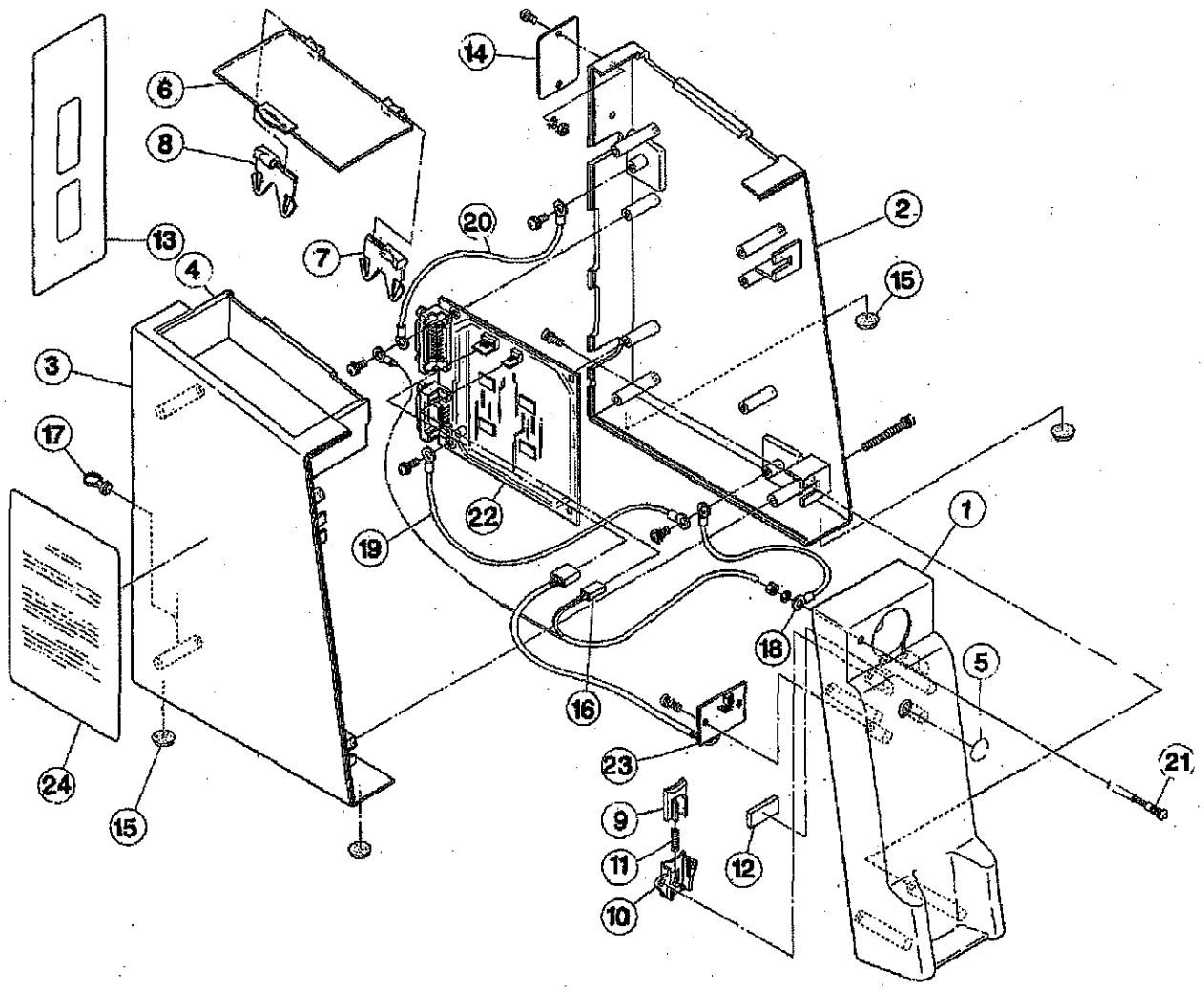
9.5 Parts Breakdown Diagram: 8800



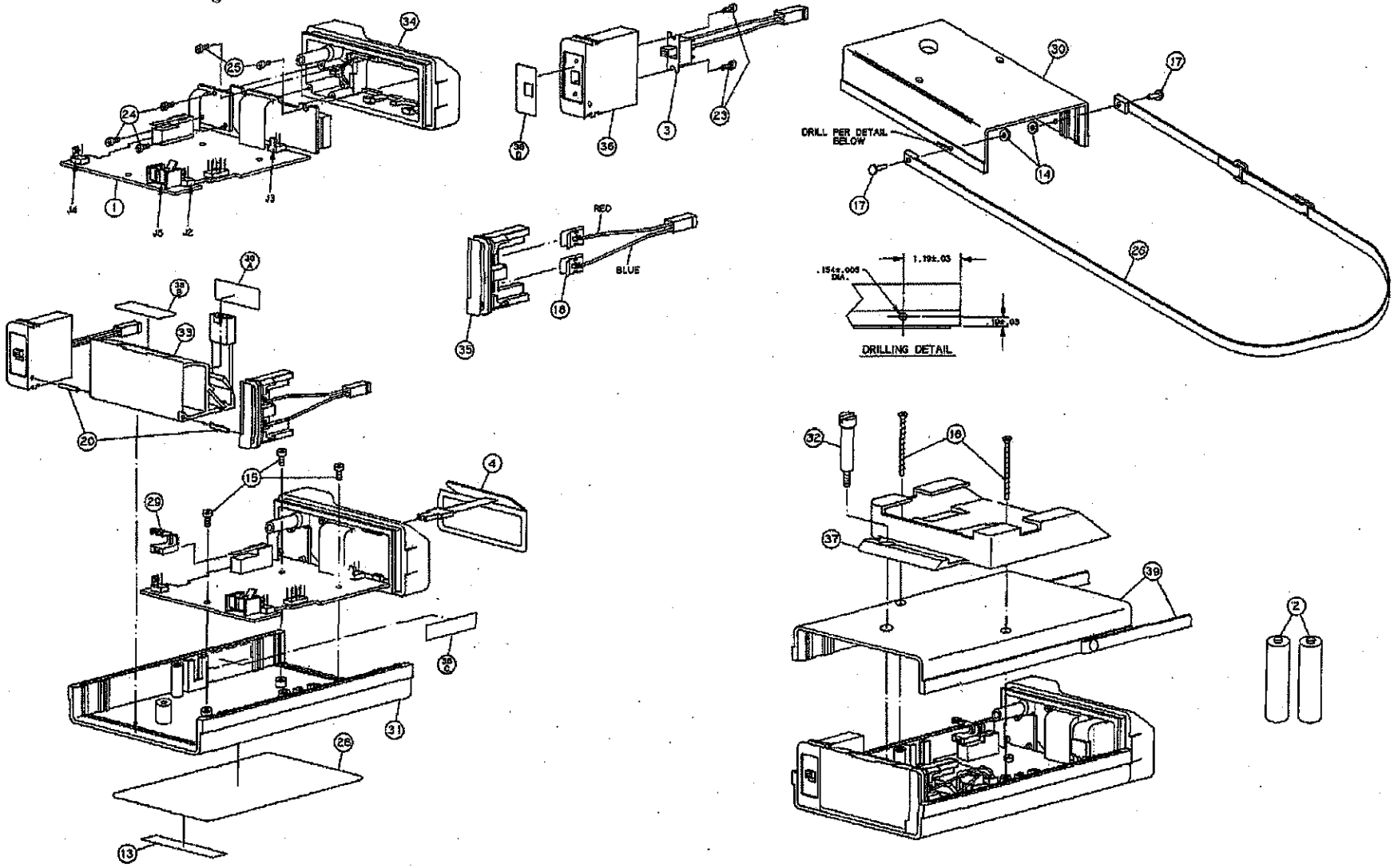
9.6 Parts Breakdown Diagram (inside): 8800



9.7 Part Breakdown Diagram: 8000MS, 8000IR, 8000N



9.8 Parts Breakdown Diagram: FILAC



10.0 Schematics

10.1 Block Diagram: 8800

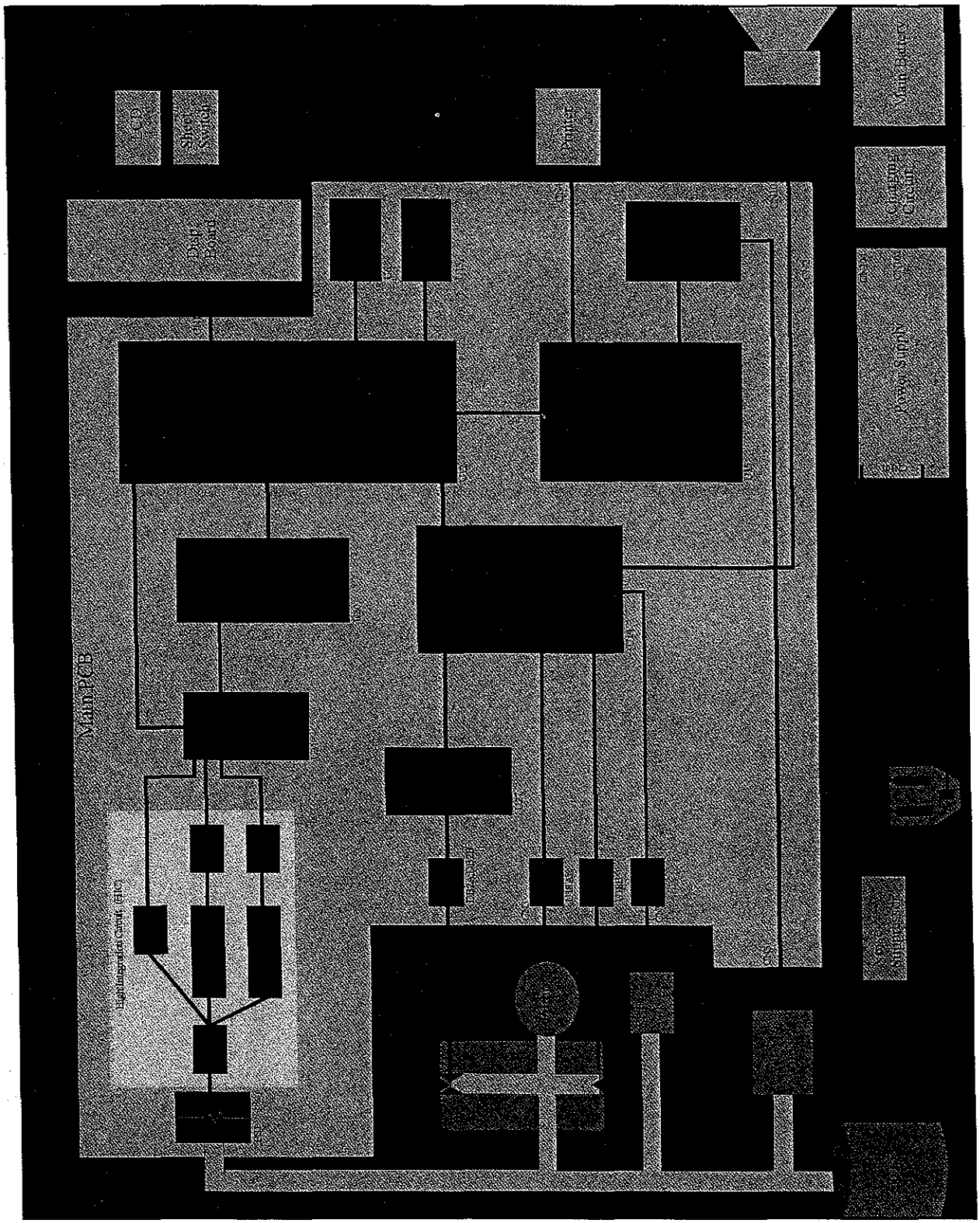


Diagram of 8800 (without Smart Features)

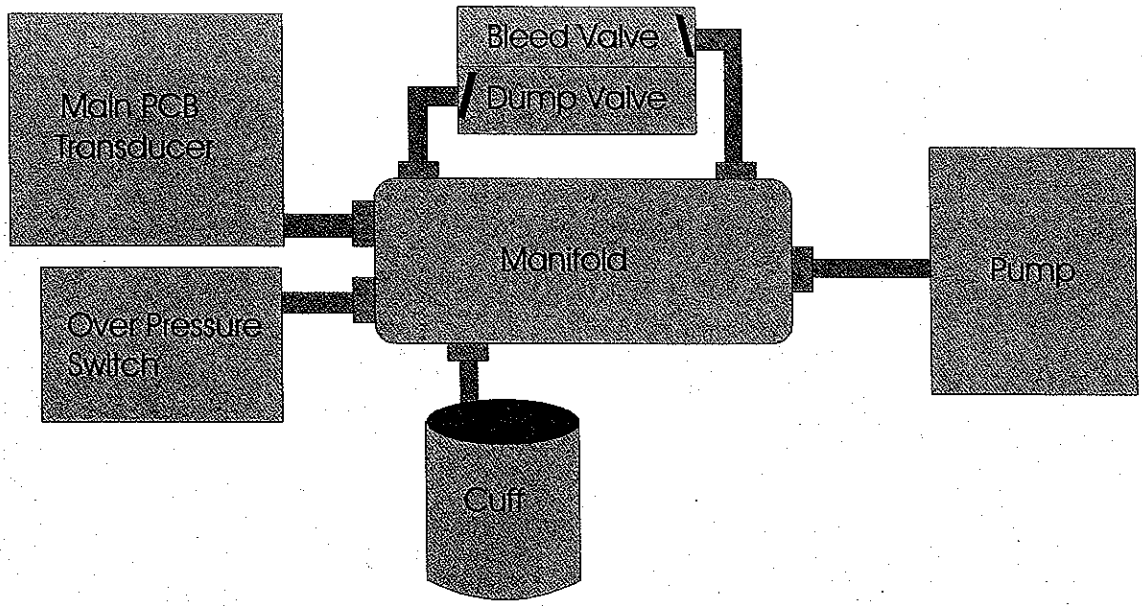
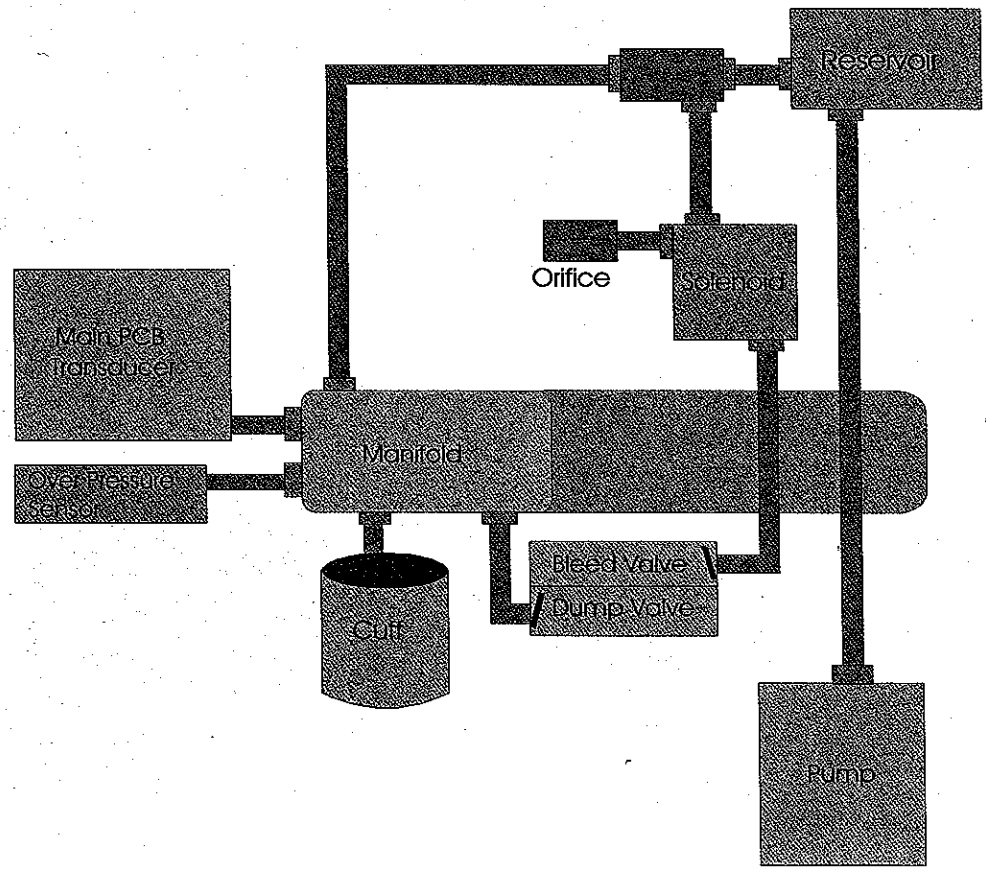
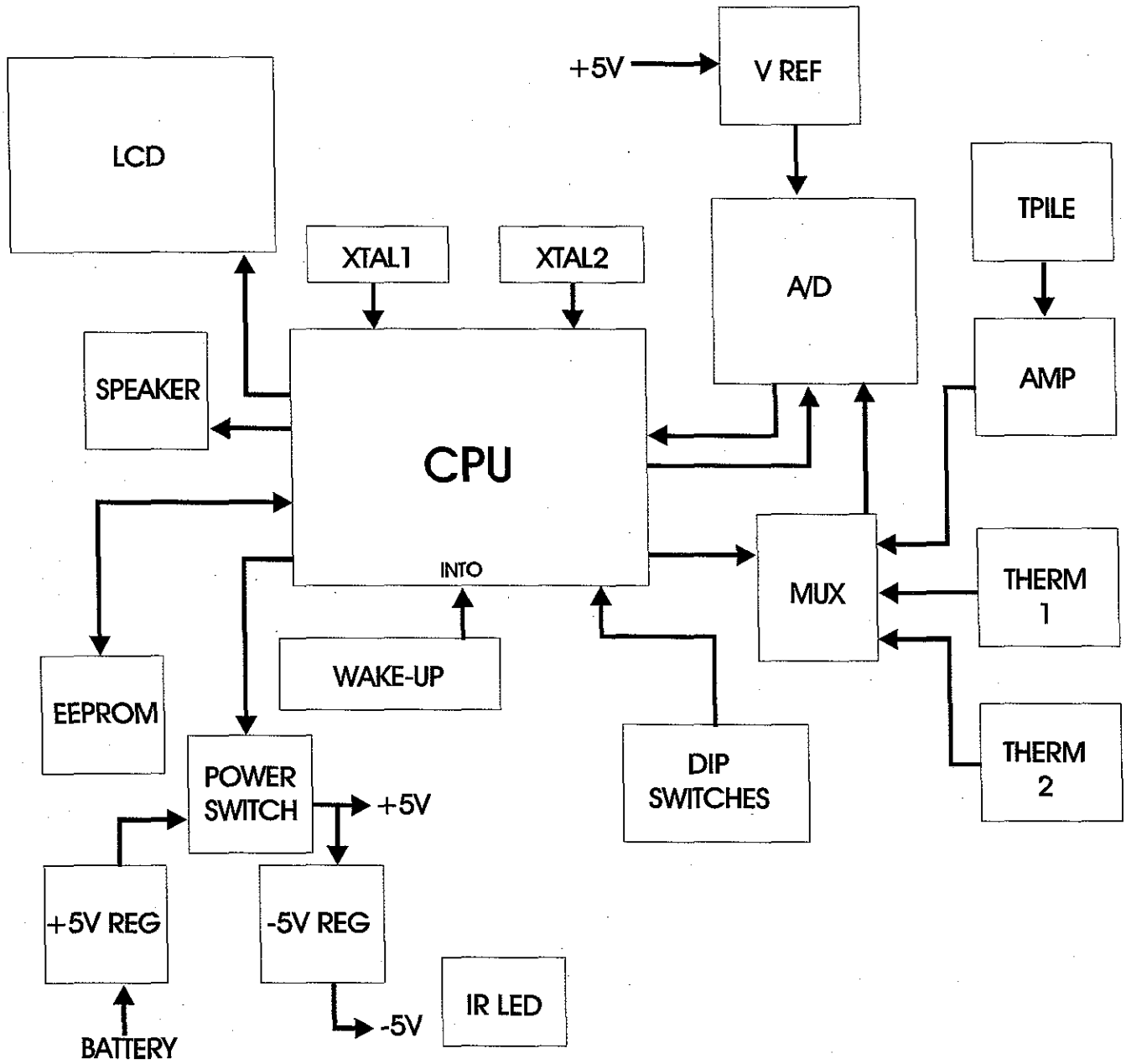


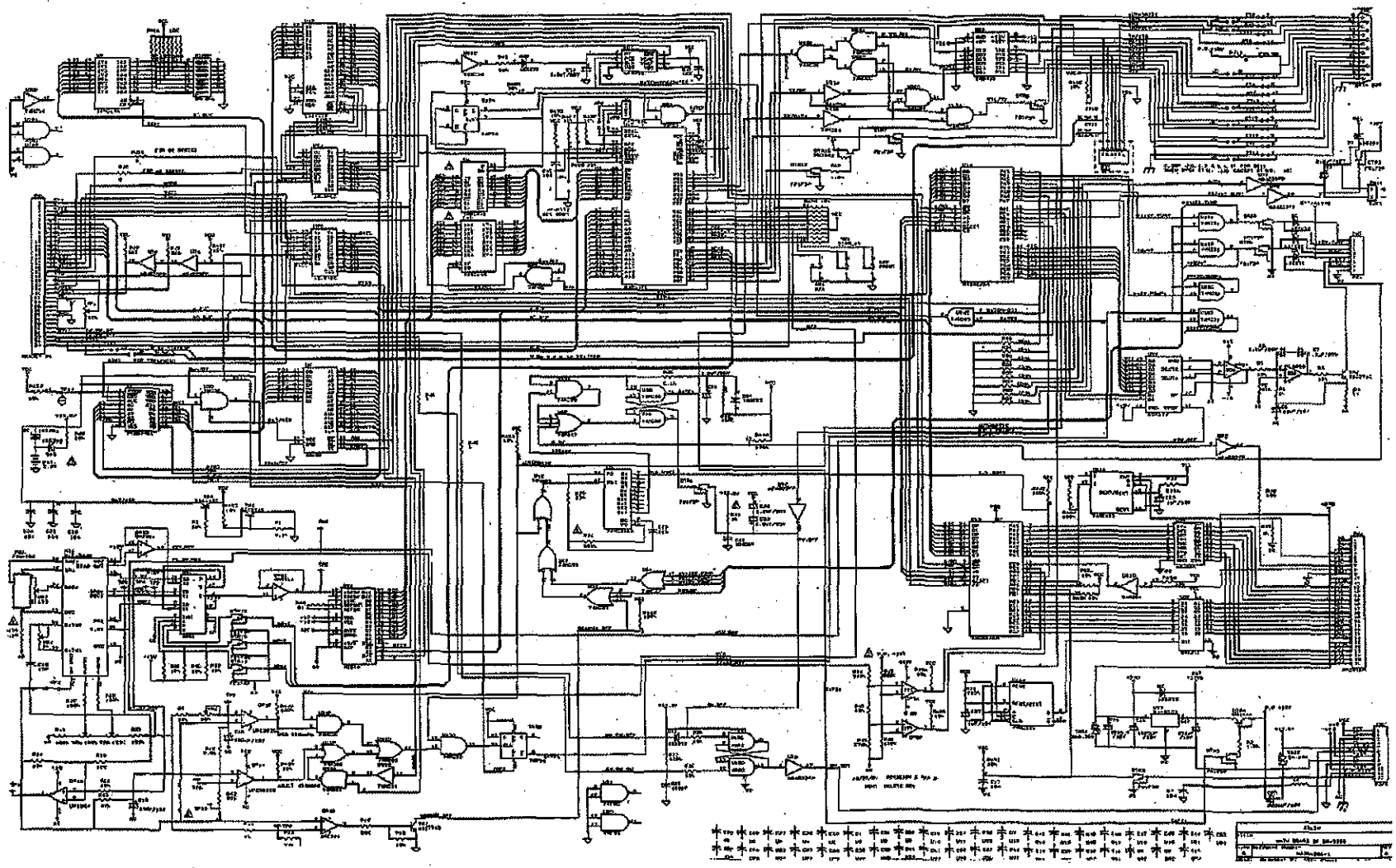
Diagram of 8800 (with Smart Features)



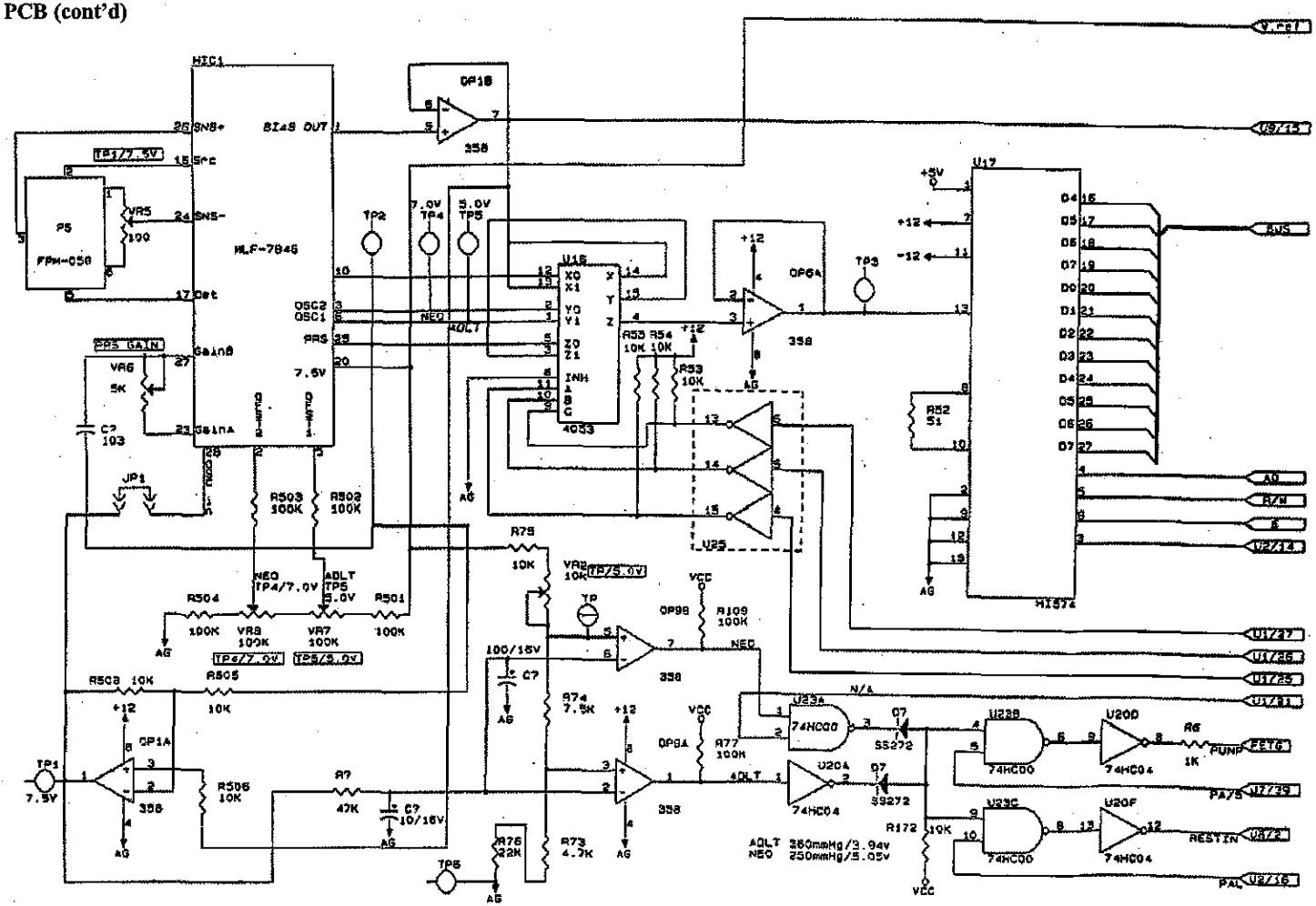
10.2 Block Diagram: Genius



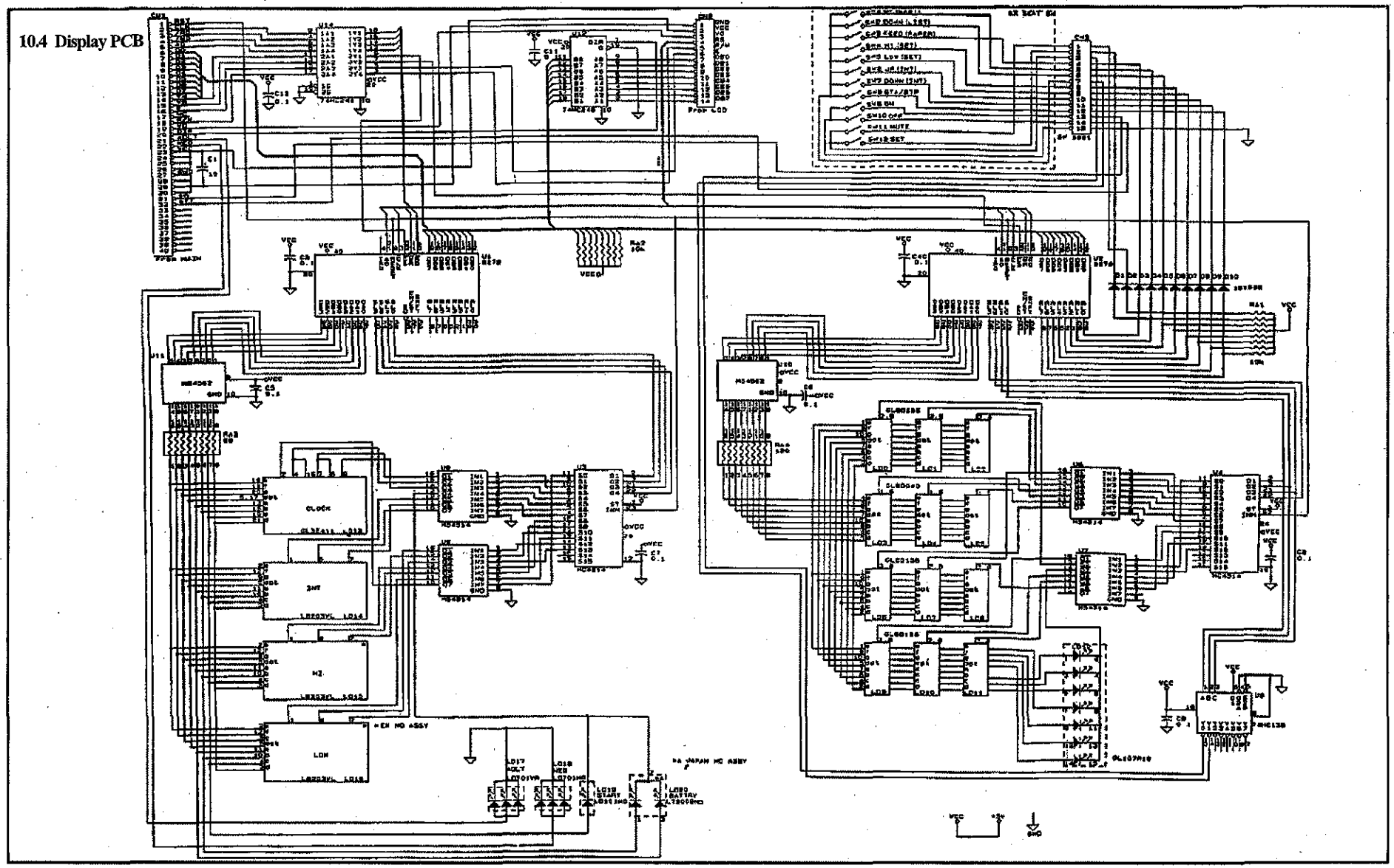
10.3 Main PCB



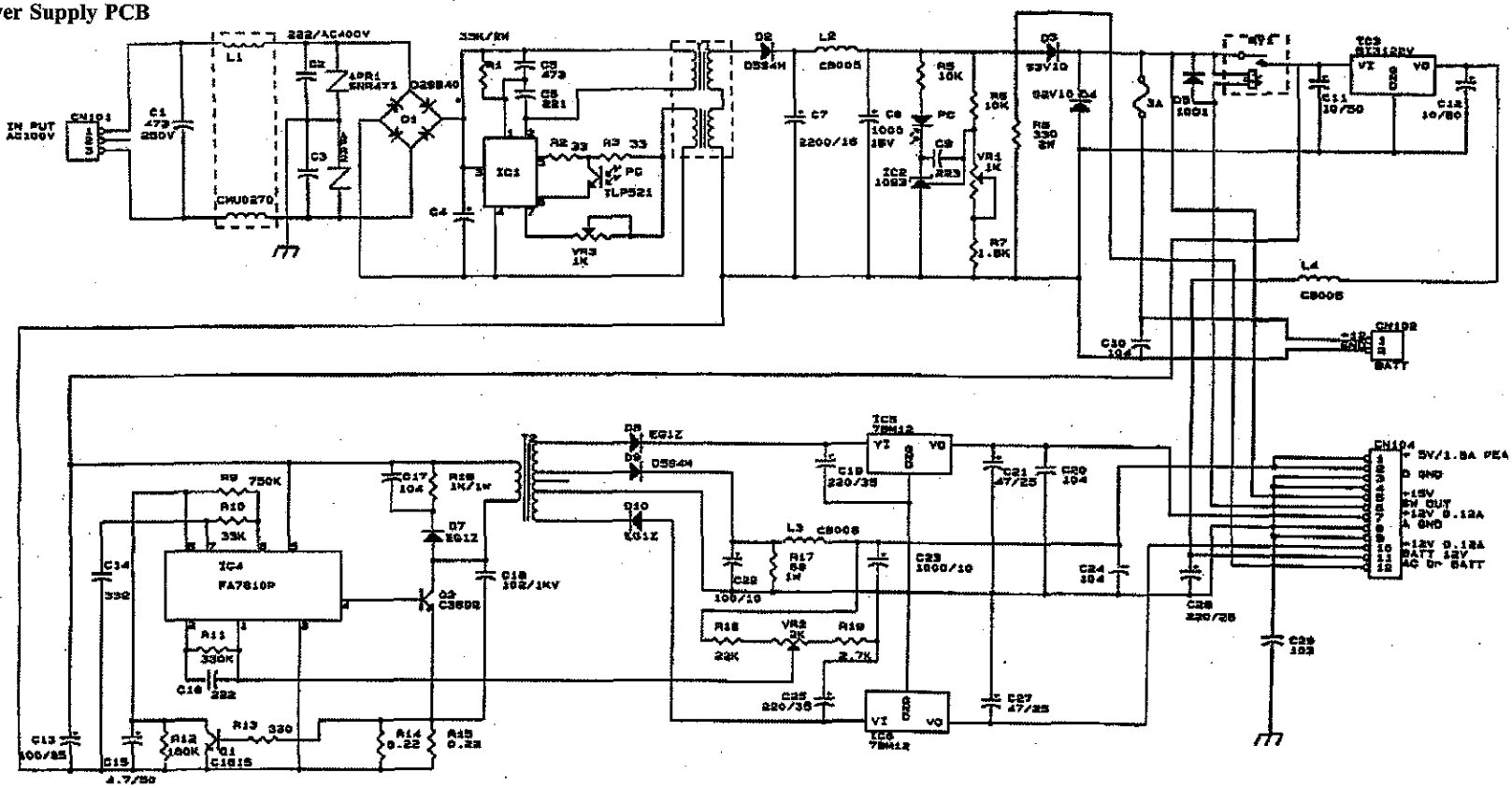
10.3 Main PCB (cont'd)



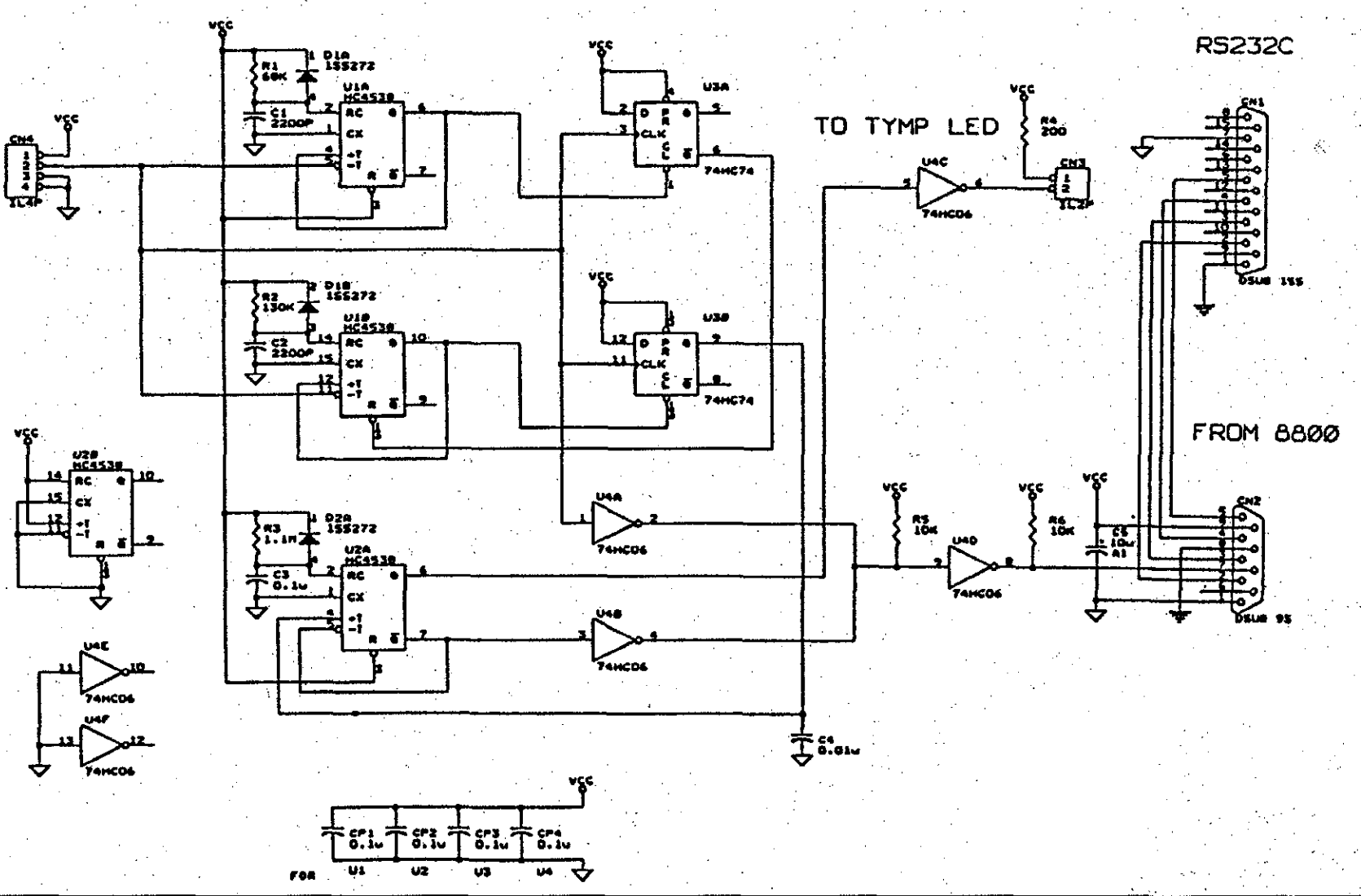
10.4 Display PCB



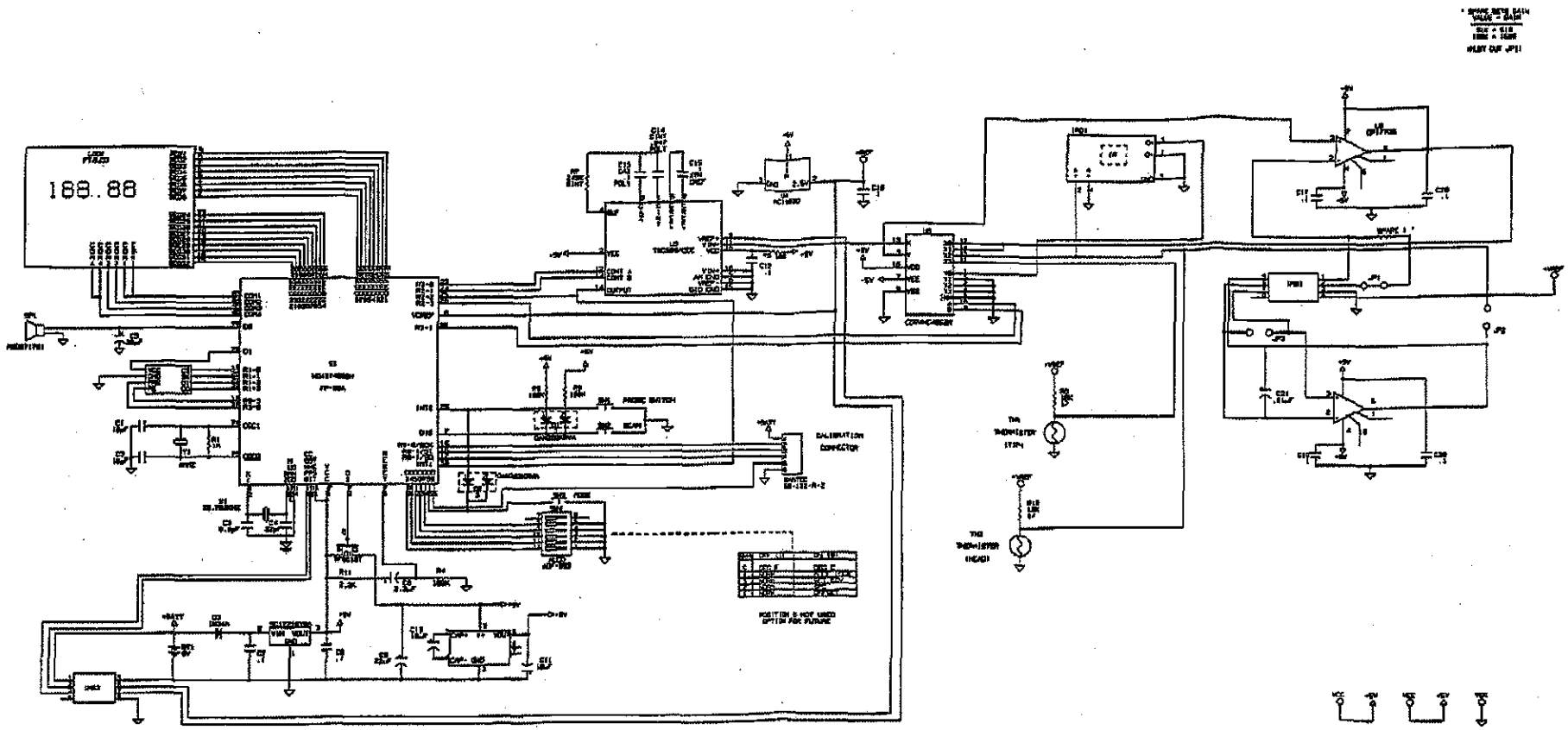
10.5 Power Supply PCB



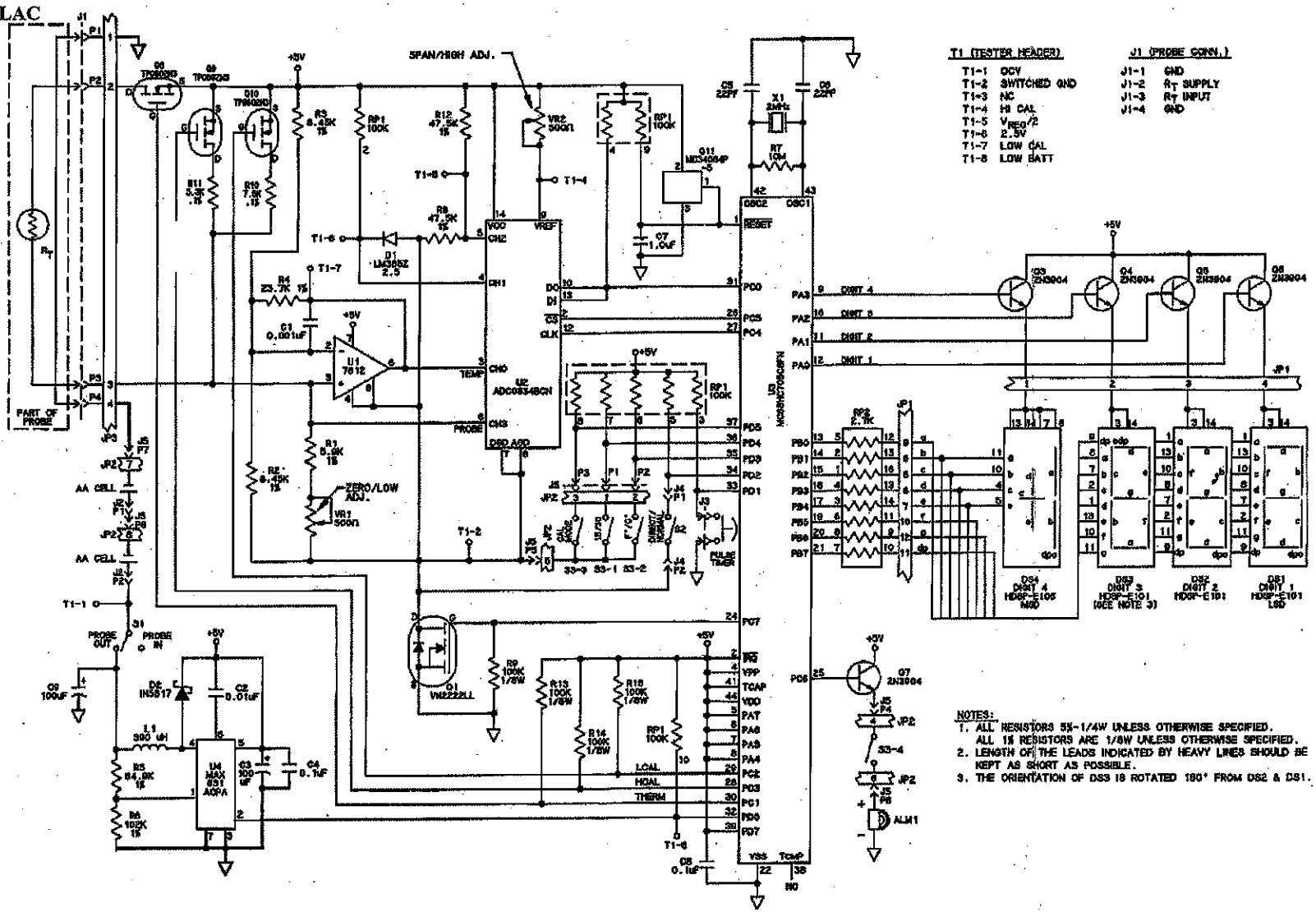
10.6 PCB: 8800IR



10.7 PCB: Genius



10.8 PCB: FILAC



11.0 Specifications for Press-Mate, Genius and FILAC

11.1 Environmental Requirements: 8800

1.	Power Supply	120 Volts AC
2.	Power Consumption	33 VA
3.	Operating Temperature	10 to 40 °C
4.	Operating Humidity	15 to 95%
5.	Storage Temperature	-20 to 70 °C
6.	Storage Humidity	5 to 95%
7.	Nominal Life	6 years

11.2 Functional Specifications

1.	Pressure Display Range		10 to 300 mmHg
2.	Display Accuracy		Within 2% range
3.	Inflation speed		2.8 to 7.3 seconds (693 cm^3 air chamber 0 to 250 mmHg)
4.	Deflation speed at pressures indicated:		
	Pressure		Speed (mmHg/sec.)
	240		4.6 to 6.2
	160		4.6 to 6.2
	80		3.3 to 5.0
	40		2.6 to 4.4
5.	Withstand voltage (between unit and primary supply)		1000 to 1250 V
6.	Leakage current		<100 uA
7.	Earth resistance		<0.1 ohm
8.	Withstand line noise voltage		
	Pulse width:	200 ns	> 1 kV
		500 ns	> 1 kV
		100 ns	> 1 kV
9.	Withstand static noise voltage		
	Normal operation guaranteed at <10 kV		

11.3 Thermal Printer

1.	Character size	2.4 x 1.5
2.	Paper width	58 mm
3.	Print width	46.1 mm
4.	Print speed	46 cps
5.	Thermal printing paper	C1780009A

11.4 Output Terminal DSUB-15

PIN NO.	
1	F.GND
2	Tx (RS232C level output)
3	Rx (RS232C level output)
4	RTS (RS232C level output)
5	CTS (RS232C level output)
6	NC
7	GND
8	NC
9	+5 V
10	Tx (TTL output)
11	Rx (TTL output)
12	RTS (TTL output)
13	CTS (TTL output)
14	+12 V ON/OFF
15	R/B (TTL)

11.5 Physical Specifications

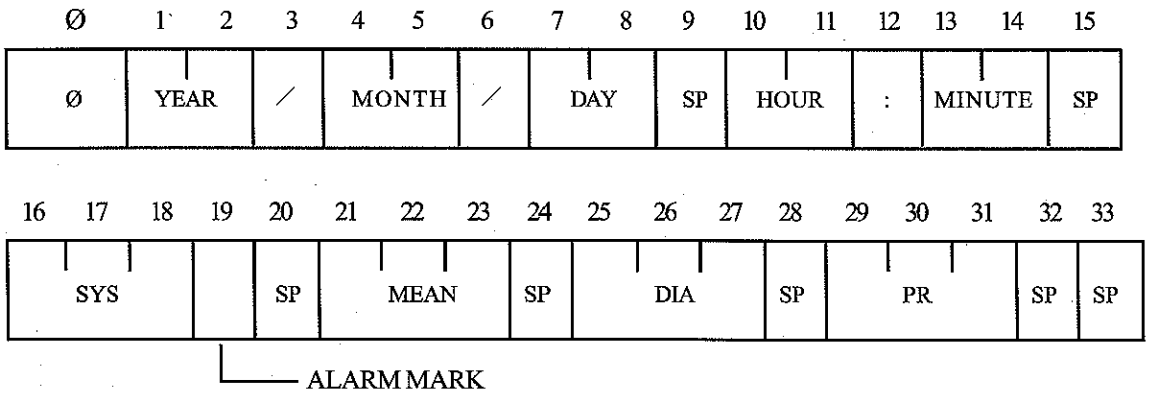
Measurement Method	Oscillometric
Display Method	LED display (for actual measurement data) LCD (stored data, error messages, and alarm settings)
Pressure Detection	Semiconductor pressure sensor
Inflation Method	Diaphragm pump driven by a DC motor
Display Range	Pressure: 10-300 mmHg Pulse Rate: 30-240 bpm
Outside Dimensions	170 (W) x 170 (D) x 228 (H) mm
Weight	Approximately (4.8Kg)
Power Supply	AC 120V±10% 60Hz
Battery	12V, 1.9AH
Battery Life	4 hrs @ 5 min. interval measurements
Storage Temp. Range	-20°C to +70°C (-20°C to +40°C for battery)

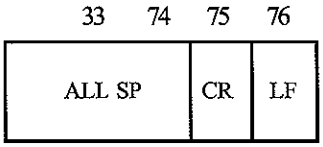
11.6 Standard Accessories

(1) Disposable Adult Cuff
(1) Adult Cuff (12 cm in width)
(1) 3.5 m pressure hose
(2) Paper Roll (for units with printers)
(1) Paper Shaft (for units with printers)
(1) AC-power cord
(2) Boxes Patient Pack Genius Probe Covers
(1) Rolling Stand
(1) Dust Cover
(1) Operations Manual

11.7 Communication Specifications

a. Asynchronous
b. 4800 bps
c. 1 start bit
d. 8 data bits
e. Even Parity
f. 1 Stop Bit
g. Ready/Busy Control by RTS/CTS Signal
Data can be received by Press-Mate when RTS signal level is HIGH. Data can be transmitted by Press-Mate when CTS signal level is HIGH.
h. RS-232C ouputs data when Temp-Mate is connected.
i. When a measurement is completed, data is output according to the format in the following diagrams:





"/" = ASCII code 2 FH
":" = ASCII code 3 AH
"SP" = ASCII code 2 ØH
"CR" = ASCII code Ø D_H
"LF" = ASCII code Ø A_H

ALARM MARK
Over higher limit - ">" = ASCII code 3 E_H
Under lower limit - "<" = ASCII code 3 C_H
Without alarm - ASCI code 2 $Ø_H$

SYS, MEAN, DIA, PR – Each value consists of 3 bytes in ASCII code.

YEAR, MONTH, DAY, HOUR, TIME – Each value consists of 2 bytes in ASCII code.
YEAR consists of 2 bytes of most significant digits of the year, e.g. 1992 = "92".

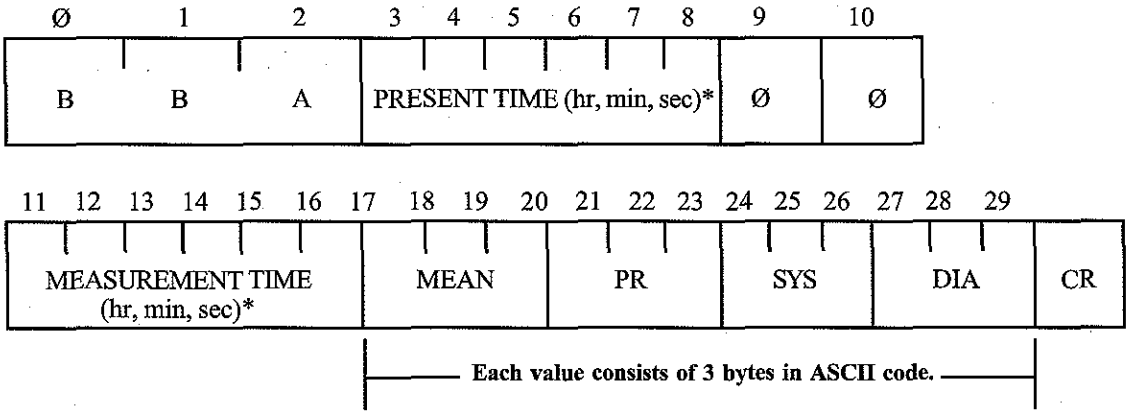
NOTE: The Mean Blood Pressure value is calculated each measurement, but is not displayed on the front panel for 8800 MS/MSP only.

Output Terminal DSUB-15 (on rear panel; Corometrics Version–Dip switch No. 4 = OFF)

1. Communication Specification
   a. 600 bps
   b. 8 data bits
   c. None parity
   d. 1 stop bit
   e. Ready/Busy control by CTS signal (Data can be transmitted from Press-Mate when CTS signal level is HIGH).

2. Output

When a measurement is completed, data is output according the following format.


Ø 1 2 3 4 5 6 7 8 9 10
B B A
PRESENT TIME (hr, min, sec)*
Ø
Ø
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
MEASUREMENT TIME (hr, min, sec)*
MEAN
PR
SYS
DIA
CR
Each value consists of 3 bytes in ASCII code.

***Each value consists of 2 bytes in ASCII code.**

11.8 Specifications: Genius

Accuracy: ±0.2°F (±0.1°C), 96°F - 102°F
Other points as specified by A.S.T.M

Temperature Range: 60°F to 110°F (15.5°C to 43.3°C), °C or °F

Ambient Temperature Operating Range: 60°F to 104°F (15.5°C to 40°C)

Storage Temperature Range: -4°F to 122°F (-20°C to 50°C)

Response Time: Approximately 1 to 2 seconds

Primary Mode: Tympanic

Resolution: 0.1°C (0.1°F) displayed on LCD

Power: One 9-volt Alkaline or Lithium battery

Battery Life: Approximately 5000 temperatures

Low Battery Warning: 2 levels on LCD screen
Level 1 – "Replace battery as soon as practical"
Level 2 – "Replace now, thermometer will not operate"

Optional Temperature Conversion: User-programmable for rectal, oral, or core equivalents (°C or °F)

Unique Features: Incorporates 15-second pulse timer. Tone generator in surface mode. Instant "In-Service Menu System (IMS)" prompts on method of use via LCD screen. May be recalibrated at user site using optional calibrator.

Size of Probe: 8.5"L x 2.2"W x 3"H

Weight of Probe: 7 oz.

Patient Pack Disposables: 21-probe covers

11.9 Specifications: FILAC

Weight: Approximately 19 ounces (excluding probe)

Dimensions: Approximately 2 3/4"H x 3/14"W x 6 1/16"L (excluding probe)

Measurement Range: 90°C to 110°F (32° to 43°C)

Display Range: ± 0.1°F or ±0.1°C

Ambient Operating Temperature: 60° to 90°F (15.6° to 32°C)

Accuracy: Meets or exceeds A.S.T.M. standard E1112

NOTE: When using a liquid bath to test the accuracy of the predictive mode, correct the final temperature as follows to compensate for the difference between in vivo and in vitro conditions.

CENTIGRADE

Range	Subtract
32.0° to 41.0°	0.6°
>41.0°	0.5°

FAHRENHEIT

Range	Subtract
89.6° to 102.0°	1.1°
102.1° to 106.0°	1.0°
>106.0°	0.5°

Pulse Timer: 15 to 30 seconds

Batteries: (2) AA cell 1.5V Alkaline

12.0 Press-Mate 8800SAT/SATP

12.1 Operations

Taking a Reading

1. Once the appropriate sensor has been applied to the patient, turn the unit on. The N-20P automatically tests its circuitry and lights the entire display. If a problem is detected, an error message is displayed.

> **NOTE**: During operation, the constant pitch beeper sounds once for each pulse, and the pulse amplitude indicator reflects pulse strength at the sensor site. If no sensor is detected, dashes are displayed.

2. During the self-test, check whether PR ON or PR OFF is displayed. To select the printer option required, push the Printer ON button, also use this button to turn the printer off.

3. To turn the N-20P off before the measurement cycle ends, rapidly press the measure button two times.

Installing Batteries

The N-20P operates on four 1.5 V alkaline "C" cell batteries. Do not use off-the-shelf rechargeable batteries; this type of battery can cause the low battery indicator to be inaccurate.

1. Remove the battery access door by pressing the battery compartment access door latch.

2. Install four alkaline "C" cell batteries. Be sure to observe the polarity indicator sticker.

3. Replace the battery cover access door.

Loading/Clearing Printer Paper

The N-20P uses a thermal paper that can show printed characters on one side only. Make sure that the paper roll is correctly installed; always refer to the graphical instruction label found on the paper roll.

1. Press down and outward on the top of the paper compartment door to remove it.

2. Feed the paper into the paper compartment slot; refer to the graphic label for orientation.

3. Press and hold the ADV button until the end of the paper appears at the paper exit slot.

4. Replace the paper compartment door.

If the paper jams either during the loading process or during printing, proceed as follows:

1. Remove both the paper door and the printer-head access cover.

2. Firmly grab and pull the paper roll backward – out and away from the print head – observe the print head access to determine whether or not the paper escaped from the jammed position.

3. If paper remains jammed between the print head and printer, press the ADV button; the jammed paper may work its way out. If the paper remains jammed, and the printer drive does not advance the paper, manually advance the drive gear on the side of the printer to free the paper.

4. If these attempts fail to free the jammed paper, remove the printer from the unit to gain full access (see Disassembly Procedure).

Setting Date and Time

The following code letters and number appear in both Oxygen Saturation and Pulse Rate display fields. The symbol "xx" represents information in the Oxygen Saturation display field and "yy" represents information in the Pulse Rate display field.

Begin this procedure by first removing any sensor from the instrument.

1. Switch on the N-20P and allow the unit run POST.

2. When dashes appear in the Oxygen Saturation and Pulse Rate displays, press the D/D (day/date) button once. At this point, the Oxygen Saturation display field shows "txx", with "t" representing time; "xx" representing hours, and "yy" representing minutes. Note that "xx" (hours) is flashing.

3. Press the ADV (advance) button repeatedly until the correct hour is displayed.

4. Press the D/D button once. Note that "yy" (minutes) is now flashing.

5. Press the ADV button repeatedly until the correct minute is displayed.

6. Press the D/D button. At this point, the Oxygen Saturation display field shows "dxx", with "d" representing date; "xx" representing the month and "yy" representing the date. Note that "xx" (month) is flashing.

7. Press the ADV button repeatedly until the correct month is displayed.

8. Press the D/D button once. Note that "yy" (date) is flashing.

9. Press the ADV button repeatedly until the correct date is displayed.

10. Press the D/D button. At this point, the Oxygen Saturation display field shows "Yxx", with "Y" representing "year". Note that "xx" (year number) is flashing.

11. Press the ADV button repeatedly until the correct year number is displayed.

12. Press the D/D button once. The N-20P turns itself off within 5 seconds.

13. Date and time are now correct. Check by switching on the N-20P with the printer enabled. After the N-20P executes its POST, the printer prints the spot check mode header with the correct date and time.

Replacing the Real-Time Clock (RTC) Battery

The socket for the RTC battery (BTI) is located on the auxiliary PCB at grid location 5D. Typical life of the clock battery is 5 years.

> **Caution**: After replacing and RTC battery, switch the instrument, on then immediately switch it off; this action will prevent possible damage to the RTC voltage circuit.

1. Disassemble the N-20P (see "Disassembly Procedure")
2. Using a thin flathead screwdriver, gently pry the RTC battery from its socket.
3. Insert a new battery into the socket, observing the polarity indication (socket's clip and battery's flat side are positive)
4. Re-assemble the unit.
5. Switch on the instrument, then immediately switch it off (the RTC voltage circuit requires this step to prevent possible damage to the unit). The instrument is now ready for normal operation.
6. Reset the clock (see "Setting Date and Time").

Replacing the PROM

A one-time-programmable PROM memory chip contains the system operations and diagnostic software. This chip (U15) is located in a socket on the main PCB. If software updates are made available from the factory, or if a problem with this chip is suspected, contact Nellcor's Technical Services Department of Nellcor's local representative for information about a replacement chip.

1. Disassemble the N-20P (see "Disassembly Procedure").
2. After noting the chip's orientation, use a PLCC extraction device to remove the chip from its socket on the main PCB.
3. Carefully insert the replacement chip into its socket. *Ensure the chip is correctly oriented.*
4. Re-assemble the unit.

> **Note the alignment marks:** a small dot at the top of the chip and a small triangle at the top edge of the socket should match up. Another key to ensuring correct orientation of the chip and socket is the notched corner of the PROM is to be located at the top left of the socket.

Replacing Fuses

Two fuses (F1 and F2) are located on the auxiliary PCB. Fuse F1 may open to protect the CPU and its associated components from damage if the power supply malfunctions. Fuse F2 may open to protect the printer from damage due to excess voltage if the printer head jams or has been physically damaged. Refer to the auxiliary PCB schematic for the locations of F1 and F2.

Replacing the DB-9 Connector

1. Disassemble the N-20P; the connector is on the main PCB at grid location 3A.

2. Using a low-power soldering iron, unsolder the connector from the PCB and remove it. *Save all Teflon tubing, ferrite blocks, and insulating materials for the replacement connector.*

3. Install ferrite blocks between plastic lead spacer on the connector and the PCB.

4. Insulate connector pin numbers 2, 3, and 5 with Teflon tubing, and insert inside ferrite block.

5. Add insulating material between each end of ferrite block and PCB, and secure with Loctite glue.

6. Solder new connector to PCB and visually check PCB for stray drops of solder before re-assembling.

7. Switch on the N-20P and test the connector with a patient sensor.

Adjusting Printer Darkness

> **CAUTION**: Adjust the printer darkness setting until the lightest legible print is visible. Setting the print darker than this could reduce printer-head life.

Although the N-20P is designed to automatically compensate for conditions that might influence the quality of the printout, the user may want to adjust the print darkness. The normal darkness setting is set at the factory; this setting maximizes both readability and print head life.

1. Switch on the N-20P in spot check mode. (Spot check mode is started by depressing the instrument measure button once.)

2. Simultaneously press and hold the ADV and ON buttons for 2 seconds. If these buttons are not pressed at the same time, two audible beeps will sound and the N-20P wither advances the paper or switches off, depending on which button press is first sensed. If the buttons are pressed at the same time, a single audible beep will sound, "Pr SEt" is displayed, and the printer prints one of the following 6 lines:

PRINTING LIGHTER	(10% lighter than normal darkness)
PRINTING LIGHT	(5% lighter than normal)
PRINTING NORMAL	(normal darkness)
PRINTING DARK	(5% darker than normal)
PRINTING DARKER	(10% darker than normal)
PRINTING DARKEST	(15% darker than normal)

> **NOTE**: The parenthetic line description is not printed, and button presses are ignored whenever the printer is printing.

3. Press the ADV button to change the darkness setting. The printer prints a line with each button press, and the setting increments from lighter to darkest and then wraps back to lighter.

4. Allow the N-20P to switch off (about 30 seconds). The last printer darkness setting is remembered when the N-20P is switched back on. Test this by repeating the procedure and skipping step 3.

12.2 Theory of Operation for N-20P

Overview

The N-20P is based on the principles of spectrophotometry and optical plethysmography. Optical plethsymography uses light absorption technology to reproduce wave forms produced by pulsatile blood. The changes that occur in the absorption of light due to vascular bed changes are reproduced by the pulse oximeter as plethysmographic wave forms.

Spectrophotometry uses various wavelengths of light to qualitatively measure light absorption through given substances. Many times each second, the N-20P passes red and infrared light into the sensor site and determines absorption. The measurements, which are taken during the arterial pulse, indicate absorption by arterial blood, non-pulsatile blood, and tissue.

By correcting "during pulse" absorption for "between pulse" absorption, the N-20P determines red and infrared absorption by pulsatile arterial blood. Because oxyhemoglobin and deoxyhemoglobin differ in red and infrared absorption, this corrected measurement can be used to determine the percent of oxyhemoglobin in arterial blood: SpO_2 is the ration of correct absorption at each wavelength.

Functional Versus Fractional Saturation

Then N-20P measures functional saturation, that is, oxygenated hemoglobin expressed as a percentage of the hemoglobin that is capable of transporting oxygen. It does not detect significant levels of dyshemoglobins. In contrast, some instruments such as the IL282 Co-oximeter measure fractional saturation, that is, oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including dyshemoglobins.

Consequently, before comparing N-20P measurement with those obtained by an instrument that measure fractional saturation, measurements must be converted as follows:

$$\text{functional saturation} = \text{fractional saturation} \times \frac{100}{100-(\%\ \text{carboxyhemoglobin} + \%\ \text{methemoglobin})}$$

Measured versus Calculated Saturation

When saturation is calculated from a blood gas measurement of the partial pressure of arterial oxygen (PaO_2), the calculated value may differ from the N-20P SpO_2 measurement. This is because the calculated saturation may not have been corrected for the effects of variables that can shift the relationship between PaO_2 and saturation.

Figure 12.1 illustrates the effect that variations in pH, temperature, partial pressure of carbon dioxide (PCO_2), and concentrations of 2,3-DPG and fetal hemoglobin may have on the oxyhemoglobin dissociation curve.

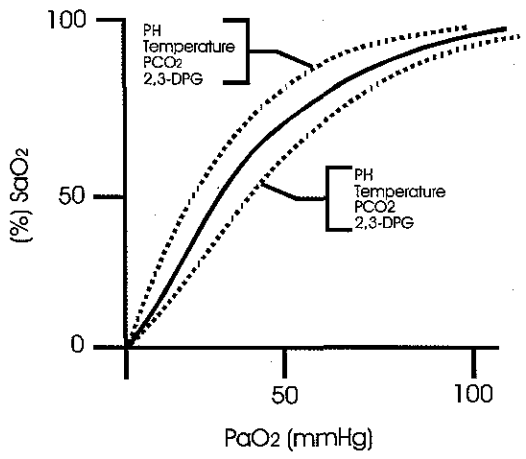


Figure 12.1 Oxyhemoglobin dissocation curve

Overview

This section provides a detailed explanation of N-20P operation using block diagrams and circuit schematics.

The N-20P consists of three main components:
1. The N020P main PCB schematic diagram.
2. The N-20P auxiliary PCB schematic diagram.
3. The N-20P flex circuit schematic diagram.

The relationship between these components and their interconnection is illustrated in the overall block diagram. The main component has been divided into the following subsections:

SpO_2 Analog Circuitry Block Diagram (Figure 12.3)
Analog circuitry has high signal sensitivity and reduced susceptibility to noise. Its design allows for a wide range of input signal levels and a broad range of pulsatile modulation. The SpO_2 analog circuit consists of four subsections:

1. Sensor output/LED control, where the CPU controls the gain of both LEDs so that signals received at the input amplifier are in its acceptable dynamic range;

2. Input signal conditioning, where sensor output current is converted to voltage;

3. Signal gain, where the separated LED signals are amplified so their current levels are within the A/D converter's acceptable range; and, AC ranging, where DC offset is eliminated from each LED signal.

Digital Circuitry Block Diagram (Figure 12.4)
The diagram shows the N-20P hardware and circuits, which include: the CPU and system memory, the power supply and power control circuitry, user controls, display and ambient light sensors, audio output, thermal printer and ambient temperature sensor, and the real-time clock.

Display Control Block Diagram (Figure 12.5)
The N-20P display is controlled by the display control circuitry. A sensor is used to measure ambient light. During low light conditions, the display backlight, an electroluminescent device, is automatically switched on.

Power Supply Block Diagram (Figure 12.6)
Power supply circuitry is located on the auxiliary PCB and consists of four subsections:

1. Four "C" size batteries that provide 4-6 VDC;

2. Power control circuitry that senses a press of the measure button and switches power on;

3. Power shut-off circuit that controls power to all circuits except the power control circuit; and

4. Power supply circuits include: a regulated power supply at 5 VDC, unregulated power supplies of -5 VDC, 10 VDC, and 12 VDC, and a high voltage power supply of 70 VDC.

Printer Control Block Diagram

Printer circuitry is divided into two subsections: the printer interface and the printer flex circuit. The printer interface circuitry is present on all models, but is disabled by software in the N-20. The printer flex circuit is added when a printer is present.

Definition of Terms

Analog to Digital (A/D) converter – The CPU has a 10-bit A/D converter on board. Up to eight different analog inputs can be provided to the A/D for measurement.

Central Processing Unit (CPU) – An intel 80C196KC 16-bit microcontroller. The CPU sends and receives control signals to the SpO_2 analog section, display, and optional printer.

Content Addressable Memory (CAM) – The CPU controls the HSO lines with the CAM. CAM is software controlled and programmed with events scheduled relative to one or two internal timers.

High Speed Outputs (HSO) – The 6 HSO lines control most of the timing of the LED signal pulse and the demodulation of the received signal.

Input and Output (I/O) – Digital lines that are used by the CPU to read in data and output data.

Light Emitting Diodes (LEDs) – Two LEDs are used in Nellcor oximetry sensors. Light is transmitted through body tissue and received by a photodetector circuit that converts it to photocurrent. The two wavelengths, which are used for calculation of pulse rate and oxygen saturation in blood, are transmitted at the following wave lengths:

infrared (IR) light at = 915 nanometers
red light at - 660 nanometers

Pulse width Modulation (PWM) – The three 8-bit PWM outputs can be software controlled; their duty cycle can be changed from 0-255/256 of the total pulse duration. PWM frequency is the crystal frequency of the CPU, which is 10 MHz divided by 1024. The PWMs control the gains within the analog circuit.

RCal – Sensor RCal value is a resistance value specific to an individual sensor. This value is used by the software during oxygen saturation computations to maximize accuracy.

Real-Time Clock (RTC) – The RTC is used with the optional printer to track time and date for printouts.

Overall Block Diagram

Exclusive of covers, button, and external connectors, the N-20P consists of three main components: the main PCB, the auxiliary PCB, and the display assembly and analog shield.

Main PCB – contains the SpO_2 analog circuitry; the CPU; support memory circuits; sensor circuits for ambient light, temperature, and battery voltage; the check battery circuit; a serial data port; and some display control circuits.

Auxiliary PCB – contains the power supply circuitry; the display driver circuits; the real-time clock; the interface circuitry for the printer flex circuit board (which is not used unless a printer is present); and audio output hardware.

Display and Analog Shield Assembly – this assembly connects to the main PCB by flex circuits. A metal shield shrouds the SpO2 analog circuits on the main PCB to protect them from EMI. An integrated electroluminescent backlight illuminates the display under low light conditions.

The N-20P has an additional printer control board (printer flex circuit), and printer hardware. The following block diagram shows the relationship between these components.

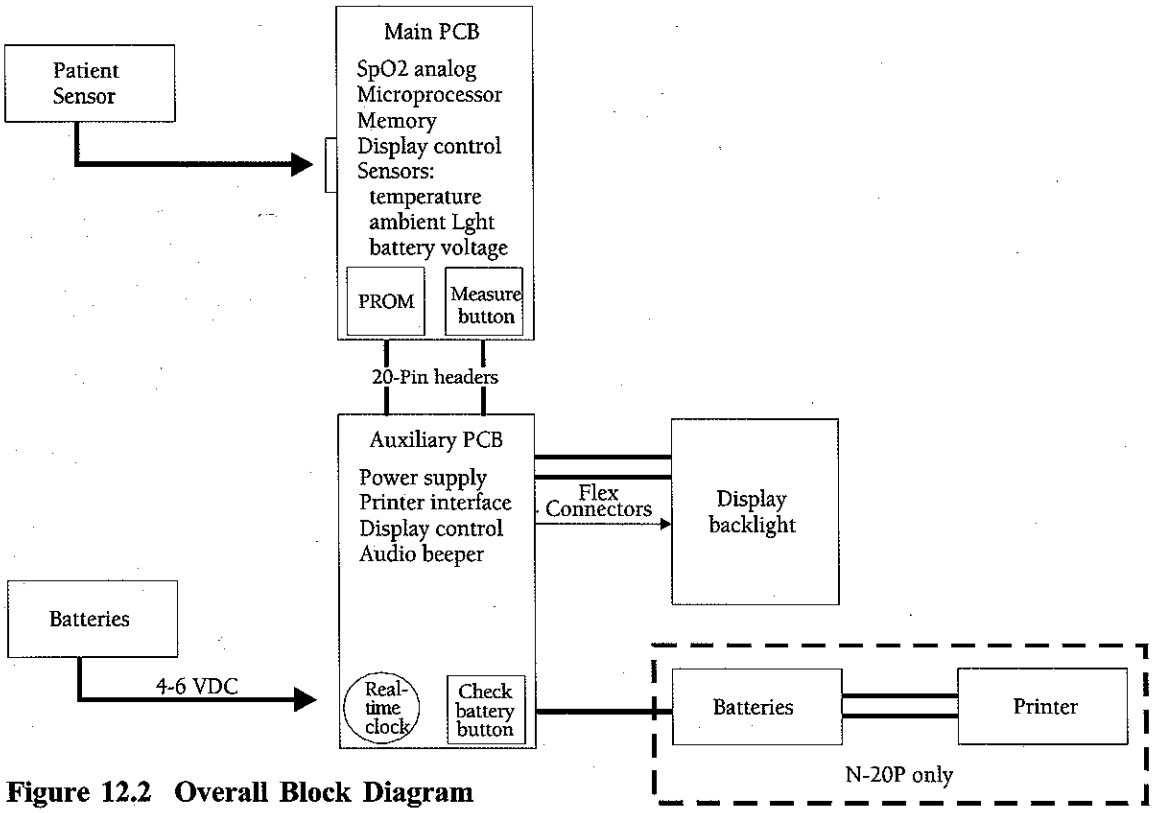


Figure 12.2 Overall Block Diagram

SpO2 Analog Circuitry

This subsection describes the SpO_2 analog hardware. The analog circuitry has high signal sensitivity and reduced susceptibility to noise. Its design allows for a wide range of input signal levels and a broad range of pulsatile modulation. The SpO_2 analog block diagram (Figure 12.3) consists of four subsections:

Sensor/output LED control – The CPU controls the gain of both LEDs so that signals received at the input amplifier are within an acceptable dynamic range. Signal channel gain may also need to be increased. The CPU uses PWM lines to control LED current level or to amplify the signal channel.

Input conditioning – Sensor output current is converted to voltage. A demodulation circuit minimizes the effects of other light sources and stray frequency inputs. Because the IR and RED signals are at different current levels, the two LED signals are demultiplexed and separately amplified, so they can be compared with each other. Two circuits handle the demultiplexing by alternately selecting LED signals using switches. Filters then remove noise and smooth the signals before sending them to the amplifiers.

Signal gain – The separated LED signals are amplified so that their current levels are within the A/D converter's acceptable range. The signals are filtered to improve the signal-to-noise ratio, and clamped to a reference voltage.

AC ranging – DC offset is eliminated from each LED signal. An analog switch sets the mean signal value to the mean of the A/D converter range, and the AC modulation is superimposed on that DC level. Then, each AC signal is amplified and filtered to eliminate residual effects of the PWM modulations. Finally, these two signals are input to the CPU A/D converter.

The relationship between these subsections is shown in the following block diagram.

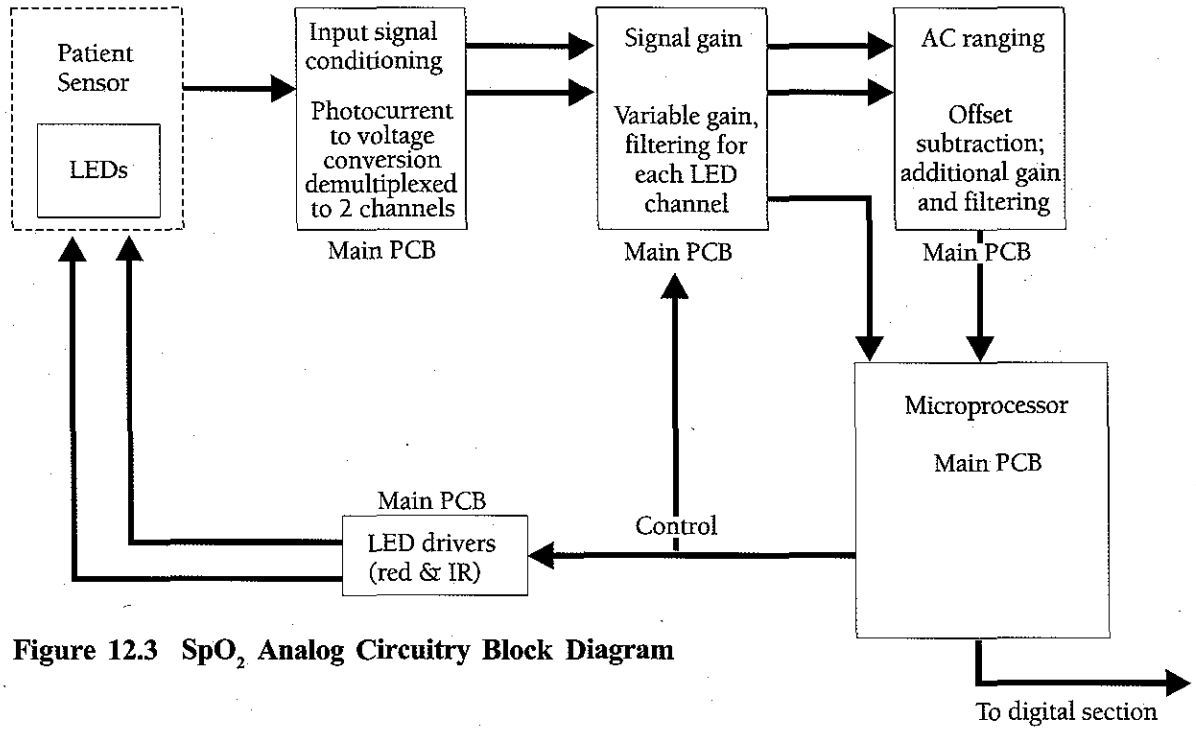


Figure 12.3 SpO_2 Analog Circuitry Block Diagram

Sensor Output/LED Control

The SpO_2 analog circuitry provides control of the red and IR LEDs such that the received signals are within the dynamic range of the input amplifier. Because excessive current to the LEDs will induce changes in their spectral output, it is sometimes necessary to increase the received signal channel gain. To that point, the CPU controls both the current to the LEDs, and the amplification in the signal channel.

At initialization of transmission, the LEDs' intensity level is based on previous running conditions; and, the transmission intensity is adjusted until the received signals match the range of the A/D converter. If the LEDs reach maximum output without the necessary signal strength, the PWMs will increase the channel gain. The PWM lines will select either a change in the LED current or signal gain, but will not do both simultaneously.

The LED circuit switches between red and IR transmission and disables both for a time between transmissions in order to provide a no-transmission reference. To prevent excessive heat build-up and prolong battery life, each LED is on for only a small portion of the duty cycle. Also, the frequency of switching is well above that of motion artifact and not a harmonic of known AC transmissions. The LED switching frequency is 1.485 kHz. The IR transmission alone, and the red transmission alone will each be on for about one-fifth of the duty cycle; this cycle is controlled by the HSO's of the CPU.

LED Drive Circuit

The IR and red LEDs are separately controlled with their drives currents multiplexed over two shared wires. Current to the IR LED is in the range of 4.3-50.0 mA; and, current to the red LED is in the range of 6.5-75.0 mA. Currents are limited to less than 100 mA for two reasons: (1) slight excess current can potentially change the emission characteristics of the LEDs, and (2) large excess current could create excessive heat at the sensor site.

The IR/red LED transmission signal (HSO1 of the CPU) is fed into the select inputs of the triple single-pol-double-throw (PDT) analog multiplexing switch U10, causing either the IR or the red LED transmission to be enabled.

PWM1, which is filtered by the network of R44, R52, and C38, is input to the LED drive circuit switch U10, and controls the magnitude of the IR LED current supply.

PWM2, which is filtered by the network of R43, C36, R53, and C39, is also input to U10, and controls the red LED current magnitude.

Two NPN transistors (Q1 and Q2) act as current sources for the IR and red LED outputs. Two PNP transistors (Q3 and Q4) act as switches between the IR and red LED output lines. Transistor Q5 acts as an LED drive current limiter; it clamps output of the current regulator circuit to the required level. If any resistor in the LED drive circuit fails, current to the LED will still be limited to a safe level.

The RSENS line senses the RCal value and enables the CPU to make the proper calculations based on the type of sensor being used.

Input Conditioning

Input to the SpO_2 analog circuit is the current output of the sensor photodiode. In order to condition the signal current, it is necessary to convert the current to voltage.

A differential synchronous demodulation circuit is used to reduce the effects of other light sources and stray frequency inputs to the system. Because the IR and red signals are absorbed differently by body tissue, their received signal intensities are at different levels. Therefore, the IR and red signals must be demodulated and then amplified separately in order to compare them to each other. Demultiplexing is accomplished by means of two circuits that alternately select the IR and red signal. Selection of the circuits is controlled by two switches that are coordinated with the IR and red transmissions. A folter with a large tiem constant follows to smooth the signal and remove noise before amplification.

Differential Synchronous Demodulation Circuit

Before the current from the photodetector is converted to voltage, any high frequency noise is filtered by C40 and R17. The op-amp UIA is used in parallel with the current-to-voltage converter UID to cancel any DC voltage, effectively AC coupling the output of UID. The average value of the SpO_2 analog reference voltage (VREF) of UID, 5 V, is measured at pin 14 of test point 49.

U6D, a single-pole-single-throw (SPST) analog switch, is controlled by the same line that controls the on/off pulsing of the LEDs. When either of the LEDs are on (the line is low and the switch is closed) U35 is used as a non-inverting amplifier. When the LEDsa re both off, U35 is used as a non-inverting amplifier. When the LEDs are both off, U35 is used in an inverting amplifier. The signal at the output of amplifier U35 is then demultiplexed.

The CPU HSO lines SAMPRED and SAMPIR, which are both active low, control SPST analog switches U6A and U6B respectively. Switch U6A is closed to sample the red signal; switch U6B is closed to sample the IR signal. The sampling rate for both switches is 10 kHz. Switching is coordinated with the LED transmission so that the IR and red signals are each sampled twice per cycle; that is, once when the LED is off (signal inverted), and once when the LED is on (signal not inverted). The filtering circuit that follows has a long time constant, thereby acting as an averaging circuit.

If the instantaneous average photocurrent (DC offset) is excessive and UID cannot bring it to VREF, the PHOTOI line to the CPU (HSI0) is activated. This action is an indication of excess ambient light into the photosensor, or the occurrence of excess noise in the input circuit. It also serves as a warning to the instrument that the sensor signal may be contaminated and causes the software to send an error message. After about 3 seconds of continuous photocurrent signal, pulse search annunciation will begin. After about 10 seconds of continuous photocurrent signal, zeros will be displayed.

Signal Gain

The separated IR and red signals are amplified so that their DC values are within the range of the A/D converter. Because the received IR and red signals are typically at different current levels, the signal gain circuits provide independent amplification of each signal as needed. The gain in these circuits is adjusted by means of the PWM lines.

After the IR and red signals are amplified, they are filtered to improve the signal-to-noise ratio and clamped to a reference voltage to prevent the combined AC and DC signal from exceeding an acceptable input voltage from the A/D converter.

Variable Gain Circuits

The two variable gain circuits are functionally equivalent. The gain of each circuit is contingent upon the signals received level and is controlled to bring each signal to -3.5 V. Each circuit uses an amplifier and one switch in the trip SPDT analog multiplexing unit U2.

The gain in each of the circuits is accomplished by means of a feedback loop, which includes one of the SPDT switches in U2. The PWMs control whether the feedback loop is connected to ground or to the amplifier output. The feedback is then averaged by C33/R25 (red), and C34/R24 (IR). The higher the value of PWM2, the greater the IR gain; the higher the value of PWM1, the greater the red gain.

Filtering Circuits

These circuits consist of two cascaded second-order filters with a break point frequency of 10 Hz. Pairs of diodes (D1/D3 and D2/D4), which are located between VREF and ground at the positive inputs of the second amplifiers, maintain the voltage output within the range of the A/D converter.

AC Ranging

In order to achieve a specified level of oxygen saturation measurement and to still use a standard type combined CPU and A/D converter, the DC offset is subtracted from each signal. Because the DC portion of the signal can be on the order of one thousand times the AC modulation, 16 bits of A/D conversion would otherwise be required to accurately compare the IR and red modulations between the combined AC and DC signals. The DC offsets are subtracted by using an analog switch to set the mean signal value to the mean of the range of the A/D converter whenever necessary. The AC modulation is then super imposed upon that DC level. This is also known as AC ranging.

Each AC signal is subsequently amplified such that its peak-to-peak values span one-fifth of the range of the A/D converter. The amplified AC signals are then filtered to remove the residual effects of the PWM modulations and, finally, are input to the CPU. The combined AC and DC signals for both IR and red signals are separately input to the A/D converter.

Offset Subtraction Circuits

Voltage dividers R22 and R41 (red), and R31 and R5 (IR), which are located between VREF and ground, establish a baseline voltage of 2.75 V at the input of the unity gain amplifiers U7C (red) and U7D (IR).

Whenever SPST analog switches U11A and U11D are closed by HSO 0 (active low), the DC portions of the IR and red signals create a charge, which is stored on C29 and C89, respectively. These capacitors hold this charge even after the switches are opened and the resulting voltage is subtracted from the combined signal–leaving only the AC modulation output. This AC signal is superimposed on the baseline voltage output by U7C and U7D. The IRDC and REDDC are then filtered and input to the CPU, and can be measured at TP58 and TP54, respectively.

AC Variable Gain Control Circuits

The AC modulations are amplified by U7A (red) and U7B (IR) and superimposed on the baseline voltages present at the output of U7D (IR) and U7C (red). The amplification is handled by means of the SPDT analog multiplexing switch U3 within the feedback loop, which increases gain as PWM0 is increased. The IRAC and RECAC are then filtered and input to the CPU, and can be measured at TP55 and TP59, respectively.

Digital Circuitry

The digital hardware and related circuitry, which is illustrated in the following block diagram, includes the following subsystems:

- CPU – A 16-bit microcontroller that includes: a serial port, watchdog timer, A/D converter with an 8-input analog multiplexer, 3-pulse width modulators, and a high speed I/O subsystem.
- System Memory – External to the CPU and consists of an 8K x 8 static RAM and a 64K x 16 EPROM.
- Real-Time Clock (RTC) – The RTC keeps track of date and time, which is printed on each printout. The RTC is powered by a lithium battery designed to last up to 5 years before needing replacement.
- Audio Output – A piezolectric ceramic beeper is used for audio output.

- Display Control – A high-visibility display provides oxygen saturation and pulse rate values. An ambient light sensor responds to low light conditions and turns on the display backlight.

- User Controls – A measure button and a battery-check button. The measure button signals the power control circuit to switch on the power supply. Press and hold the battery-check button to display a percentage of useful life remaining in the batteries.

- Power Supply/Power Control Circuitry – The N-20P receives power from 4 "C" cell batteries. The power control circuitry discontinues power to the unit when the batteries are no longer reliable.

- Thermal Printer – Generates a hardcopy of oxygen saturation and pulse rate values. A sensor monitors ambient temperature and adjusts printer output to ensure consistent print quality.

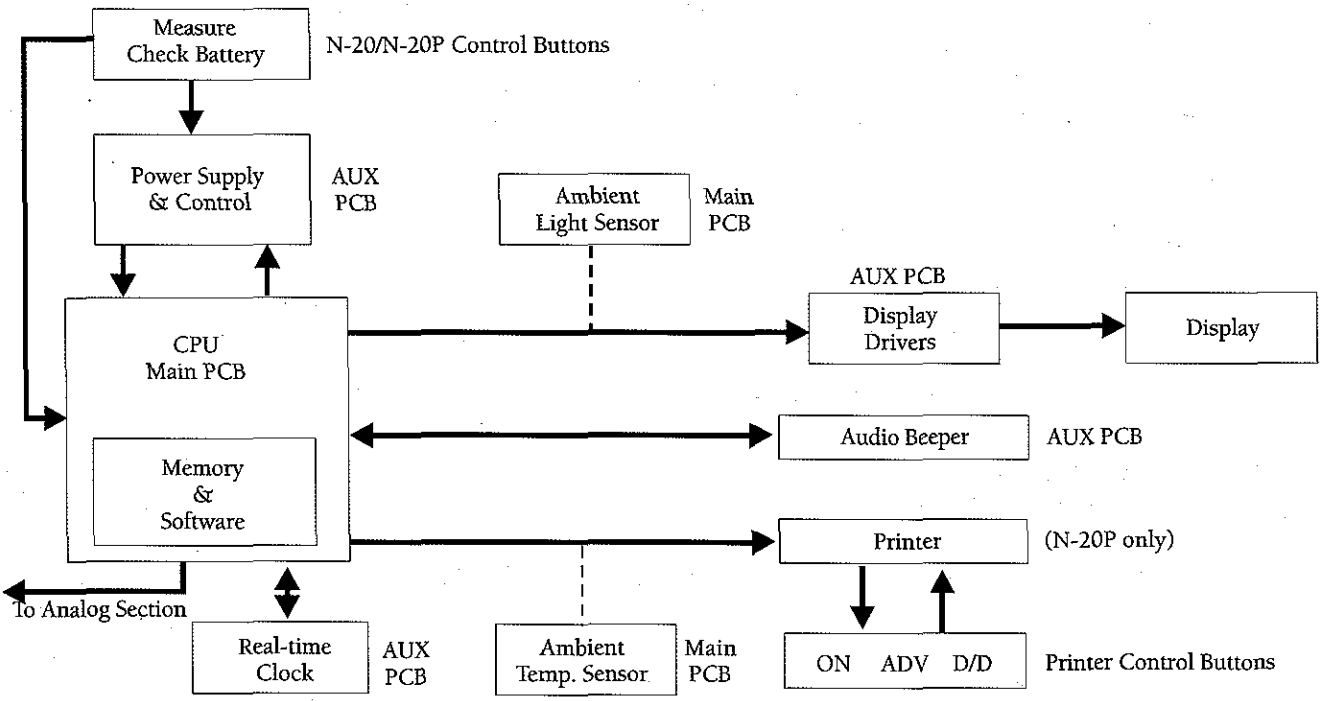


Figure 12.4 Digital Circuitry Block Diagram

CPU

The Intel 80C196KC CPU is a 16-bit microcontroller with built-in peripherals including: a serial port, watchdog timer, A/D converter with an 8-input analog multiplexer, three pulse width modulators, two 16-bit counter/timers, up to 48 I/O lines, and a high speed I/O subsystem.

The CPU is capable of running up to 16 MHz; but, it is run at 10 MHz for decreased power consumption. All unused inputs are tied to either Vcc or ground through resistors – this prevents unused inputs floating to any voltage and causing excess power drain. The READY input pin is tied high, thereby disabling wait-state generation; all bus accesses are zero-wait state. The EA pin is tied low to enable addressing of the external EPROM.

When the power supply is first switched on by the power control circuit, the reset generation circuit holds the CPU RESET pin low for at least 20 ms, then allows the internal pull-up resistor to bring it high; this assures a good CPU reset.

An internal watchdog timer is enabled and runs continuously. The watchdog timer provides a means of recovering from a software upset caused by ESD, EMI, etc. If the software does not clear the timer at least every 64K state-times (13.1 ms), the CPU will drive RESET low, resetting the entire unit. The reset output by the CPU is only 16 state-times long (3.2 s). Q22 provides isolation from C65 so the CPU can drive a good reset to the display control circuit.

The CPU has the ability to dynamically switch the data bus width–based on the BUSWIDTH input pin. A low on BUSWIDTH tells the CPU to access memory only 8 bits at a time. When accessing the static RAM, BUSWIDTH is low, automatically reading the 8-bit wide RAM. Since BUSWIDTH is connected to the active low RAM enable line (RAMEN), all other memory and mapped I/O are read or written 16 bits at a time.

Eight analog inputs are measured by the CPU. Input from the SpO_2 analog section includes AC and DC signals for the oximeter sensor red and infrared channels, and the sensor calibration resistor RSENS. Light, temperature, and battery voltage are also measured.

The N-20P CPU is configured as follows:

- Decoded AD0 and BHE generates separate WR write strobes for the low and high bytes of a word. The signal WR (pin WRL) is the low-byte write strobe.
- A standard address latch enable (ALE) is generated and used.
- HSO pins 4 and 5 are configured as outputs. The HSO is used to generate stable timing control signals to the SpO_2 analog section, display, and printer.
- The timer-2 external control pins: T2CLK, T2RST, T2U-D, and T2CAPT are disabled via software and used as standard I/O.
- The HOLD, HLDA, and BREQ bus accessing is disabled via software and the pins are used as standard I/O.
- Pins HS10 and EXTINT are configured for interrupt input. The CPU receives 2 external interrupts (signals PR TACH and PHOTO1)
- RXD and TXD are configured as a standard asynchronous serial transmitter and receiver for the serial interface.
- PWM0, PWM1, and PWM2 pins are configured as pulse width modulator outputs. They are used to control gains within the SpO2 analog section.

Address Demultipleixing

U13 and U33 are transparent latches that latch the address portion of the AD bus data on the falling edge of ALE; the outputs are always enabled. The outputs of U13 and U33 are always the address portion of the AD bus.

Address Decoding

The CPU has a 64K byte address range of 0-FFFF. RAM, EPROM, and I/O ports share this space. The address decoding circuit splits up this space and output enable lines to the RAM, EPROM, and I/O ports.

U30A generates the static RAMs active low enable signal, RAMEN. When address lines A13, A14, A15 are all high, U30As output goes low, enabling the RAM. This occurs for the 8K address range of E000-FFFF.

U30B and U28 are used to generate the input port and output port active low enable signals EXINEN and EXOUTEN. When address lines A15, A14, A11, and A10 are high, and A13 is low, U28 becomes enabled. With U28 enabled, one of the 8 outputs is set low. The output to go low is selected by pins A, B and C. They form a 3-bit binary number with pin C being the most significant bit. So when address line A12 is high, WR active (low) and RD inactive (high), a binary 5 is produced on pins A, B, and C, forcing output Y5 (EXOUTEN) low. This enables the output port for writing. When address line A12 is high, WR inactive and RD active, a binary 3 is produced on pins A, B, and C, forcing output Y3 (EXINEN) low. Note that in both previous conditions, A15, A14, A12, A11, and A10 are high and A13 is low.

The input port and the output port both share the same 1K byte address space of DC00-DFFF. When data are written to the address, the output port enable signal EXOUTEN is activated. But when data are read from the same address, EXINEN is activated. Because the CPU is configured to use a 16-bit bus, except for RAM, any even address in the DC00-DFF range could be used for external port access. In other words, reading or writing address DC00, DC02, DC04, etc., will all produce the same results. Due to the CPU configuration, the write strobe WR (WRL pin), is only active for low-byte writes; therefore, both bytes of the external output port must be written to at the same time. The upper byte of the output port cannot be written to alone, no write strobe and, therefore, no EXOUTEN signal will be generated.

U30C generates the EPROMs active low enable signal, ROMEN. The active low signals RAMEN and EXINEN are basically used as EPROM disable signals. When RAMEN or EXINEN or test point TP71 are low, the output of U30C, ROMEN, is forced high, disabling the ROM. Therefore, the EPROM is disabled for the range DC00-FFFF and enabled for the 55K byte address range of 0h-DBFF. TP71 is used during board testing to disable the EPROM.

CPU Memory

The memory system external to the CPU consists of an 8K x 8 static RAM(U14) and a 64K x 16 EPROM (U15). The EPROM is 16-bits wide to enhance CPU performance. Because RAM is infrequently accessed, it is only 8 bits wide.

U14 is a standard 8K x 8 static RAM. Test point TP 43 is used during testing to disable the output.

The program that the CPU runs is stored in U15. U15 is a 16-bit wide output, one-time programmable (OTP) EPROM. During 16-bit wide bus accesses, the CPU uses address line A0 for low/high byte selection; and is not used as a normal address line. The CPU can only address 64K x 8 bytes or 32K x 16 bytes. Pin A15 of U15 is tied low, always selecting the lower half of the EPROM. Signal ROMEN is then used to enable the EPROM for the proper memory area.

Input Port

U16 is the input port external to the CPU. The logic levels on the inputs (pins D1-D8) are output to the CPU via the AD bus while EXINEN is strobed low. All of the user control buttons are input via U16. Also, the battery type is sensed via U16; a high on signal BATTYPE signifies to the CPU that rechargeable batteries are being used. If the optional printer head is in the home position. PR HOME will be a logic high.

Pin D8 (RTC_IO) and an output bit of the external output port arc connected. They work as a pair to create a bidirectional bit for communicating with the RTC (see"Real-Time Clock and Non-Volatile Memory").

Output Port

The output port external to the CPU consists of 2 octal D latches, U18 and U17; they function as a single 16-bit output port. U18 is the lower byte (LSB) and U17 is the upper byte (MSB). The output of U18 is always enabled. The output bits of U18 control: audio output, optional printer, RTC, and display.

The signal PR STROBE controls U17s output drivers. Under normal operation, the outputs are tristated and resistors R148-R154 pull the outputs low. PR STROBE is driven low to turn on the output drivers of U17. Signals PR DOT0-PR_DOT6 (pins Q1-Q7) drive the 7 print dots of the optional printer. PR STROBE pulses all 7 of the dot lines for a specific time period (see also "Printer Interface"). When the CPU is first powered on, PR STROBE is in a tristate condition. R123 assures that U17 does not accidentally turn on the printer head dots until required to. Pin Q8 (RTC_IO) and an input bit of the external input port are connected. They work as a pair to create a bidirectional bit for communicating with the RTC (see also "Real-Time Clock and Non-Volatile Memory").

Both bytes of external output port (i.e., U18 and U17) must be written to at the same time. The upper byte of the output port (U17) cannot be written to independently (see also "Address Decoding").

Real-Time Clock (RTC) and Non-Volatile Memory

The RTC has two functions: (1) it provides non-volatile memory that is used to remember whether the printer should be enabled at power on, and (2) to keep track of time and date for the N-20P printer. The N-20 does not require or use the RTC; it is disabled via software.

The RTC chip U29 uses a 3-wire synchronous serial interface to communicate with the CPU. The CPU brings signal RTC_RST high to activate communication with the RTC. RTC CLK clocks data into and out of the RTC chip. RTC 10 is the bidirectional communication data bit. The CPU drives RTC 10 when writing data and commands to the RTC. The CPU tristates RTC 10 and then reads data back on it from the RTC.

Crystal Y1 provides an accurate 32.768 KHz clock input whenever the time keeping circuitry of U29 is activated. The CPU only enables the timekeeping function when an optional printer is installed. If no printer is installed, the RTC clock is only used during diagnostic testing to verify the CPU clock timing.

The lithium battery BT1 and diodes CR23 provide the power switch over and constant power needed to keep the time and RAM data while the unit is not in use. Whenever the unit is powered on, Vcc is at 5 V and U29 is powered via CR22. CR23 is reverse biased because BT1 at 3 V is at a lower potential than Vcc. Whenever the unit is powered off, the potential between Vcc and switched ground is 0 V, CR23 is forward biased, and U29 is powered by BT1. CR22 is reverse biased, isolating BT1 from Vcc. This circuit design allows BT1 life of up to 5 years, typical, without the unit being powered on.

U29 holds 24 bytes of RAM, which is used for non-volatile storage of CPU data.

Audio Output

BZ1, a piezo ceramic sounder, is the audio output device. Due to its low drive current of 2 mA maximum, no drive circuitry is needed and is driven directly from the external output port. It is differentially driven with 2 square waves 180 degrees out of phase. The drive frequency is approximately 1480 Hz or 740 Hz and is generated by the CPU. BZ1 is differentially driven to obtain maximum audible volume.

Display Control Circuitry

The Taliq display is controlled by the display control circuitry. A photosensor measures ambient light and automatically switches on the electroluminescent display backlight during low light conditions. The display control circuitry is divided into the following subsections.

- Control Conditioning Circuit (main PCB) – The control conditioning circuit processes signals generated by the CPU to produce timing signals for the display drivers.
- Display Driver ICs (auxiliary PCB) – Each of the two display driver ICs have 32 high-voltage outputs that enable individual segments of the display to be turned on or off.
- High Voltage Control Circuit (auxiliary PCB) – The high voltage control circuit allows the CPU to switch on or off the display's high voltage input.

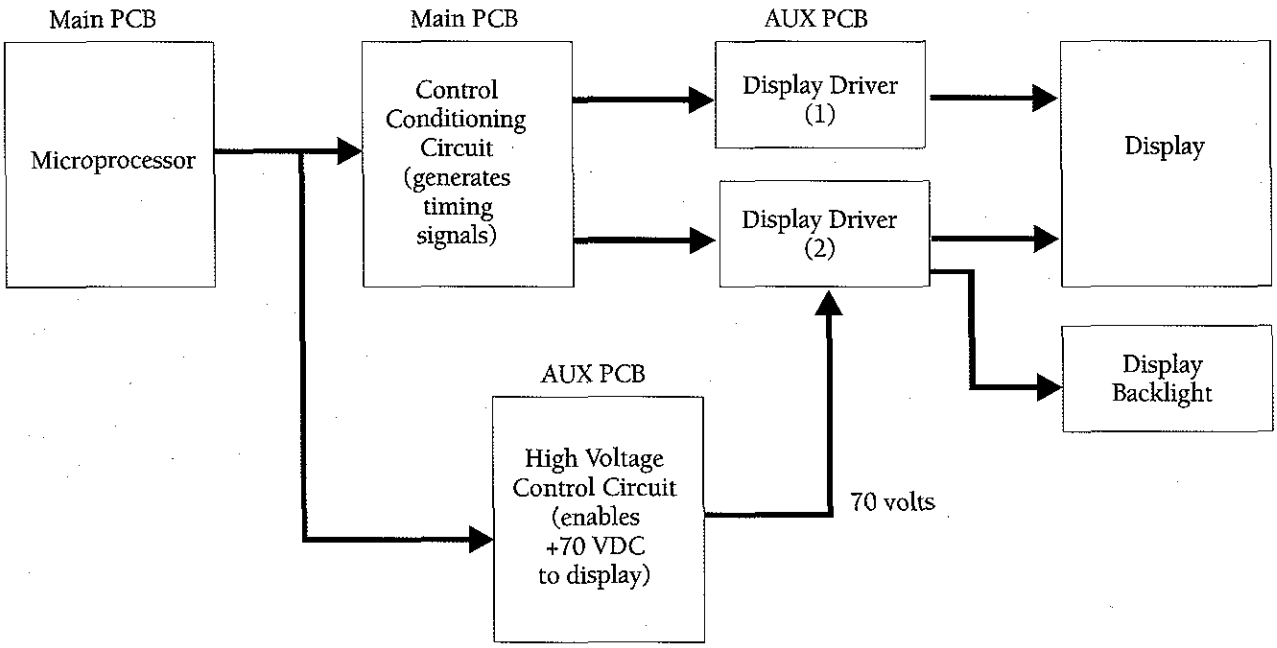


Figure 12.5 Display Control Block Diagram

Control Conditioning Circuit

The CPU generates a 400 s low pulse rate train at a 160 Hz rate on signal DISP PHASE. Half of U34 takes DISP PHASE as an input and creates DISP POL as an 80 Hz 50% duty cycle square wave. A CPU reset initializes DISP POL low when any CPU reset occurs so the software knows the initial state. The other half of U34 is used to synchronize the rising edge of the DISP DL iwht the rising edge of DISP POL. The CPU brings DISP LATCH signal high before the rising edge of DISP PHASE; this allows the high to be clocked out to DISP DL on the rising edge of DISP PHASE. About 100 s after the rising edge of DISP PHASE, the CPU brings IDSP LATCH low, asynchronously resetting DISP DL low.

Display Driver Control Circuits

U19 and U20 are the display segment driver chips. Each chip has 32 high-voltage outputs and a display common marked BP (backplane). The display data are input to U19 and U20 by the CPU via a serial shift register input. U19 and U20 are daisy-chained together forming a 64-bit serial shift register. Display data are loaded and shifted down via the DISP DATA and DISP CLK signals When all 64 bits of the shift register are loaded, a high pulse on DISP DL updates the display, all 64 bits at the same time. The display is clocked with an 80 Hz 50% duty cycle waveform by signal DISP POL. The display cannot be driven by DC voltages or display damage will result. Display segments are illuminated by creating a 180-degree phase shift between the segment pin and the BP common pin. Segments are left dark by making the waveform on the segment pin be in phase with the BP pin. The display has an electroluminescent (EL) backlight, and is driven the same as the display segments. Connectors JP2, JP3, and JP5 connect the display and EL backlight to the drive electronics.

High Voltage Control Circuit

The cold switch circuit performs two basic functions: (1) it allows the CPU to enable and disable the display high voltage VDISP, and (2) it slows the edge slew rate of the segment drivers as it switches the high voltage. When the signal DISP PHASE is low, Q14 is disabled, pulling VDISP low. Whenever the CPU is powered on, DISP PHASE is tristated. The base emitter junction of Q12 pulls DISP PHASE low, disabling the high voltage. This assures that the high voltage is only enabled to the display when controlled by the CPU.

The Taliq display is similar to an LCD in that the load of a segment is mainly capacitive. A cold switch circuit provides a current-limited 70 V to VDISP. R93, R95, Q21 and Q14 do the on/off switching and current limiting. As the driver chips' output waveforms and DISP PHASE change states, the capacitive output current is integrated into the display capacitive loads, causing a highly linear rising and falling voltage ramp on VDISP. Because the high voltage to the drive chips (VDISP) is ramped, the outputs of the driver chips U19 and U20 are also ramped at the same controlled rate. This design is used to reduce current spikes on the 70 V power supply, and, in addition, reduces the EMI generated by the display due to the lower slew rates of the high voltage switching signals.

Standard User Controls

The standard user controls consist of two momentary push-button switches (measure and check-battery). The measure button is an elastomeric contact switch, and the check-battery button is a mechanical momentary switch.

The CPU input lines BAT BTN an GO BTN are normally pulled to the high state by R71 and R78. Whenever a button is depressed, the CPU input line is pulled low through R74 and R80. The switch contacts are debounced with C64 and C66. L11, L12, C126, and C123 provide a current path for ESD protection.

In addition to being read by the CPU, the measure button also activates the power supply via the power control circuit. Note that the measure button has circuitry on both the main PCB as well as the auxiliary PCB.

Power Supply/Power Control Circuitry

Power supply circuitry is located on the auxiliary PCB and consist of the following subsections:

- Batteries – Four 1.5 V alkaline "C" size batteries provide 4-6 VDC power.
- Power control circuitry – Power control circuitry is connected to the batteries. It senses any press of the measure button and switches on the power supplies. Reverse current limiting protects the N-20P from damage if batteries are inserted incorrectly.
- Power shut-off circuit – This circuit controls power to all circuits except the power control circuit. In addition, a fuse protects the power supply from excessive current draw. The power supply is also protected against electrostatic discharge and electromagnetic interference.
- Power supply circuits consist of the following power supplies:

  Regulated power supply: Power supplied by the batteries is regulated at 5 VDC. This supply is used by all of the digital circuitry and some of the SpO_2 analog circuitry.

  Unregulated power supplies: 5 VDC is connected by a switched capacitor network into unregulated power supplies of -5 VDC, 10 VDC, and 12 VDC, all of which are used in the SpO_2 analog circuits.

  High voltage power supply: A voltage regulator/doubler converts battery voltage to 70 VDC; this increase in voltage is needed by the display drivers as well as the display backlight.

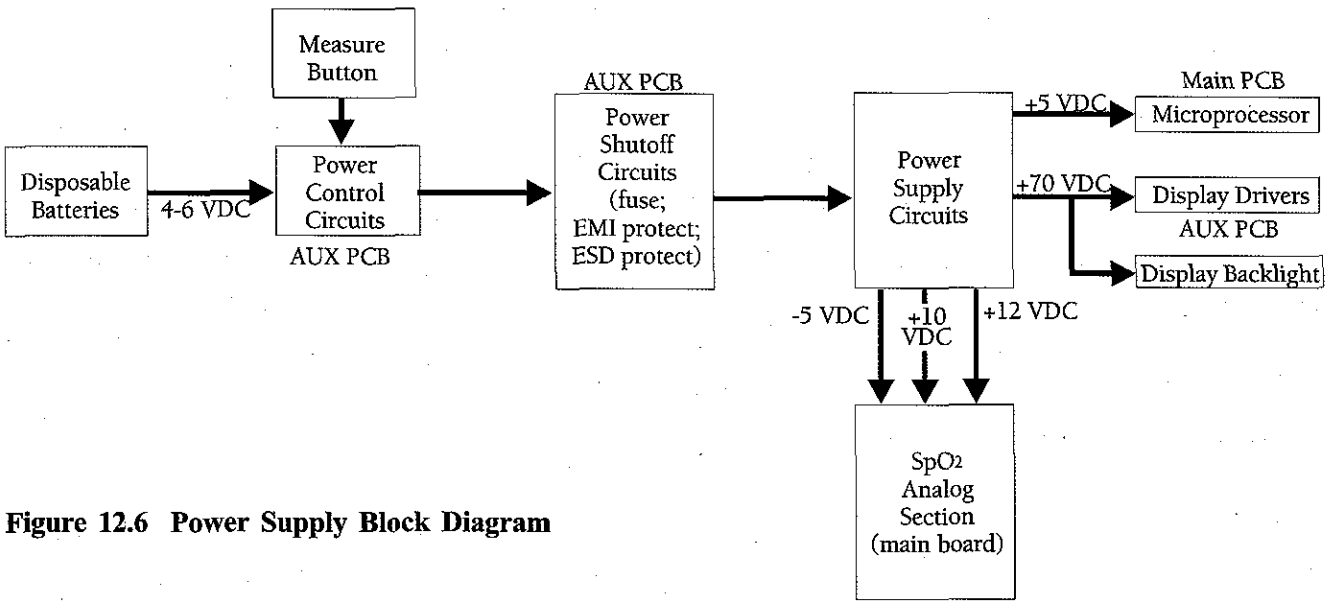


Figure 12.6 Power Supply Block Diagram

Power Control Circuitry

The power control circuit consists of U21 and its associated components. U21 is a D flip/flop with asynchronous preset and clear; only the preset and clear are used.

Power is applied to U21 via CR11 whenever batteries are installed. CR11 provides protection for U21 if the batteries are installed with reverse polarity. This error condition will reverse bias CR11, thereby disabling current flow to U21.

The much larger RC time constant of R110, C67 compared to R78, C66 guarantees that the unit will not be accidentally powered on when batteries are first installed.

Whenever the measure button is pressed, a low on GO SW sets the output signal PWR ON high. This condition connects switched and battery grounds, enables the power supplies, and switches on the unit. Whenever the CPU determines that the power should be switched off, it forces PWR DOWN low. This action clears output PWR ON to a logic low, disconnecting ground, and switching off the power supplies (see also "Power Supply").

R79 and R81 provide current limit protection to U21 inputs. They also limit the current that will flow through U21 inputs to the CPU when the batteries are installed backwards. In the reverse battery error condition, massive current can flow from the inputs of U21 through the input protection diodes and/or substrate inside the CPUs integrated circuit. These resistors limit that current path to safe levels.

Power Shut-off Circuit

Fuse F1 protects the unit from excessive current draw. CR24 protects against large voltage transients caused by ESD, EMI, etc.

Q15 is a dual-channel FET; the drain of Q15 part 2 (pin D2) is connected to battery ground; the gate (G2) is connected to battery plus; and R155 applies a bias to the source (S2) so it will switch on when a positive voltage is applied to G2. When batteries are correctly installed, Q15 part 2 is switched on and conducts. If batteries are installed backward, Q15 part 2 switches off and disables current flow. This protects the units power supply circuitry from an accidental reversal of battery potential.

Q15 part 1 controls the power supplies. When a logic high is placed on the gate (pin G1) signal PWR ON battery ground is connected to the circuit and switched to ground via Q15 parts 1 and 2. When the power control circuitry pulls PWR ON low, switched ground switches to a high impedance state. This action switches off the power supply, and therefore the unit, except for the power control circuit.

Vcc Power Supply

The Vcc power supply is a switched inductor voltage regulator operating in boost mode (U22). The power input is provided by the batteries (VBAT). NFET (Q17) operates as a linear post regulator. The I M resistor (R77) operates as a static bleed device across the switched regulator when the regulator is switched down. The regulated output is Vcc (5 V ± 5%).

Raw Power Supplies

The input to the raw power supplies is VCC, which is a switched-capacitor voltage converter operating in separate multiply and invert modes in conjunction with supporting circuitry. U23 inverts Vcc and outputs raw -5 V. Raw 10 V is derived by voltage doubling Vcc with CR14, CR19, CR20, and CR78. Raw 12 V is derived by voltage tripling Vcc with CR15, Q8, Q9, C96, C81, R119, and R120.

The raw power supplies are used as bias supplies for the SpO_2 analog section and are not tightly regulated. The normal operating range of the raw power supplies are:

raw -5.0 V	=	-6.0 V to -4.0 V
raw 10.0 V	=	7.5 V to 11.0 V
raw 12.0 V	=	12.0 V to 15.0 V

High Voltage Supply

The input power for the high voltage supply is provided by the batteries (VBAT). The high voltage supply is a switched-inductor voltage regulator (U26) that operates in conjunction with a capacitive voltage doubler to output 72 VDC + 5%. To protect against a runaway voltage condition, CR25 clamps U26's output to a safe level.

Serial Interface

The serial interface is only used for test purposes, and is not at the RS-232 level, neither is it electrically isolated and, therefore, cannot be used when the unit is connected to a patient. The serial data port JP1 is a TTL level serial interface. RXD and TXD are configured as a standard asynchronous serial transmitter and receiver at 19.2 Kbaud with 1 stop bit, 8 data bits, and no parity. The serial interface can operate in full duplex mode.

Ferrite beads L6, L7, and capacitors C120, C121 provide ESD protection for the CPU. If no serial port is connected, R128 pulls RXD input low; this action prevents an unused input from floating.

Analog Reference Voltage

U32 provides an accurate, regulated voltage that is used as the reference voltage for the A/D inside the CPU. Filtering is provided by C6, C12, and R124. The voltage output VREF is 5 V.

Ambient Light

Diode D8 is a photodiode that is used to measure ambient light. Q8, R68, and R136 provide current gain for D8s photocurrent. The amplified photocurrent flowing through R136 creates a voltage drop, which is measured by the CPU. The CPU continually monitors the light source output at AMB LIGHT (TP72). Under low ambient light conditions, the CPU automatically switches on the display backlight.

Ambient Temperature

U5 is a precision-temperature sensor. It outputs (PR TEMP) a voltage proportional to the ambient temperature, which is 10 mV per degree centigrade. For example, at a room temperature of 25°C, the U5 output would be 250 mV. U5 is used whenever an optional printer is installed, because the printer is a thermal printer, ambient temperature must be compensated for.

Battery Voltage

The analog input voltage range of the CPU is 0-5 VDC. Because the battery voltage may be as high as 6.2 V, R69 and R70 form a voltage divider to decrease the measured battery voltage to a usable level. The gain is 0.75; thus, if the battery voltage was 6 V, then the voltage of BAT VOLT would be 6 x 0.75 which equals 4.5 V.

The software has the ability to determine when battery power is too low. If the software determines that the battery voltage is too low to provide accurate information, the software generates an audible signal and automatically switches the unit off. If an optional printer is installed, the battery voltage data are used to compensate for battery voltage changes that can affect printout quality.

Battery Type

The unit can operate with either disposable or rechargeable batteries. Battery type input is digital; a high input informs the CPU that rechargeable batteries are in use. If rechargeable batteries are used, the battery and the VRECHARGE terminals are mechanically connected. This applies the battery voltage to VRECHARGE, pulling BAT TYPE high. R100 and CR27 are a current-limiting resistor and a voltage-clamping diode that are used to protect the input port from excessive battery voltage. If disposable batteries are used, VRECHARGE is electrically isolated, which allows R101 to pull BAT TYPE input low.

The nominal voltages and voltage discharged curves are significantly different between rechargeable and disposable batteries. In order for the CPU to predict how much "battery life" remains, the nominal voltage and discharge curves must be known; the BAT TYPE signal provides that information.

Printer Control

Printer circuitry is divided into two subsections: the printer interface and the printer flex circuit. Printer interface circuitry is present on both models, but is disabled by software in the N-20.

- Printer interface circuit (auxiliary PCB) – This circuit detects the presence of the flex circuit, and supplies power to the printer heads and paper advance motor. Electrical noise generated by the printer motor is filtered. The circuitry is protected from excessive battery currents by a fuse.

- Printer flex circuit (N-20P only) – The printer flex circuit is added when the printer is present. The printer generates a timing signal that is read by the CPU and sent to the flex circuit. This circuit signals the CPU that a printer is present by connecting one CPU input to ground. Power and power control signals from the auxiliary PCB generate an output load for a resistor array; heat from this process produces a dot matrix pattern on thermal paper.

User control is provided by momentary push buttons: ON (on/off), ADV (advance), and D/D (day/date). ON enables or disables the printer, ADV controls the advance of printer paper, and D/D sets date, time, and other clock parameters.

When a low battery voltage condition is present, the N-20P adjusts power to the printer's head; however, a weak battery voltage condition causes the printer to shut off, thereby allowing the N-20P to continue to display oxygen saturation and pulse rate readings until the batteries are exhausted. An ambient temperature sensor adjusts printout quality to compensate for environmental conditions.

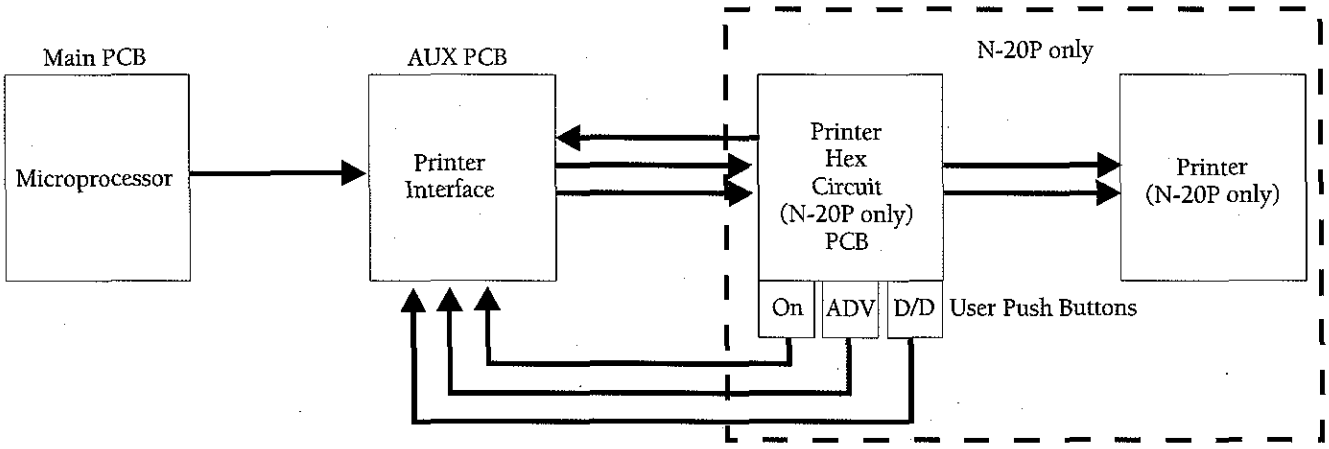


Figure 12.7 Printer Control Block Diagram

Printer Interface Circuit

The following is a description of the printer interface circuitry found on all N-20P auxiliary PCBs.

The CPU reads the PR PRESENT signal to determine if a printer is installed. With PR PRESENT left floating, it is pulled high by the weak pull-up resistor inside the CPU. If a printer is installed, PR PRESENT is connected to switched ground, which causes a low input to the CPU. The optional printer circuit is protected from excessive battery currents by fuse F2. CR28 is used to block noise generated by the printer motor being injected onto the batteries.

The N-20P printer is a 16-character-wide thermal dot matrix printer, which generates a CPU interrupt for every dot column. The thermal energy given to the print head is controlled by the pulse width of the active high signals PR DOTx. In order to provide consistent print quality, the ambient temperature, print drive voltage, and print head resistance must be measured and accounted for.

Inside the print head are seven resistors that heat up when power is applied, and in turn create dark dots on the thermal paper. One lead of the print-head resistors is connected to the printer supply voltage VPRN; the other lead is connected to the driver chip (see "Optional Printer Flex Circuit with User Controls"). One of the print dot resistor leads (DOT4) is also fed back to the printer interface circuitry. The DOT4 signal is a print dot resistor with a range of 11-16 ohms, which is connected to VPRN.

The print head resistance is measured by U36. A two-level resistor bridge is formed by R143, R144, R145, R146, and head resistor DOT4. The resistor bridge is switched on when PR MEAS is pulled high, pulling TP77 low and biasing the resistor bridge. The logic outputs of PR HEAD1 and PR HEAD2 are read in by the CPU to determine which of the three head resistance categories this particular head is. R156 ensures that Q20 does not switch on when the batteries are installed backward. Due to the large current draw of the resistor bridge and the fact that the head resistance does not change significantly over time, the head resistance is only measured once at every power on.

The CPU starts the printer motor running by setting PR MOTOR high. A single motor drives both the print head and paper advance mechanisms. The printer provides a printer timing generator (TG) signal, which is an AC waveform of about 4 Vpp. Q19, R106, R142, and CR29 convert the AC waveform to a CMOS level square wave; this signal (PR TACH) is then used as a CPU interrupt line. An interrupt routine services the printer, thereby producing the required dot patterns to create the characters. C127 is used to filter noise.

The position of the print head is sensed by the signal PR HOME. Whenever the print head is not in the home position, a switch in the printer closes, shorting PR HOME to switched ground. Whenever the print head is in the home position, the switch opens, allowing R118 to pull PR HOME high.

The print head dot pattern and pulse width are controlled by the CPU. The proper printer dot values are loaded into the output port, then the proper pulse width is loaded into the CPU CAM for PR STROBE. The signal PR STROBE enables the outputs for the specified pulse width. When the PR DOTX lines are high, a dot will be printed.

Printer Flex Circuit and User Controls

The thermal printer is plugged in via connectors JP10 and JP11. The PR PRESENT signal is connected to switched ground to tell the CPU that a printer is installed. U1 is a Darlington pair driver chip that is used to drive the printer dots and motor. When an input is high, the output is shorted to the ground, driving the output load.

Constant power (VPRN) and a power control line (PWR ON) are provided by the auxiliary PCB. Q1 is used as a power control FET. Both halves are used in parallel to reduce the on resistance. When PWR ON is high, the sources (S1, S2) short to the drains (D1, D2), connecting ground to U1 and C3. PWR ON also controls the regulated power supplies; thus, Q1 and the power supplies are both enabled and disabled at the same time.

The large bulk capacitor C3 is required due to the large current spikes that are required by the printer and the large internal series resistance of disposable batteries. Bulk capacitance is required to lessen the battery voltage drop by the current spikes.

The N-20P has three additional user-control buttons. L8, L9, L10, C120, C121, and C122 provide ESD protection. R103, R104, and R105 provide pull-ups when the user buttons are open. These pull up resistors are in the printer interface circuit to ensure that the buttons (ON, ADV, and D/D) are never left floating, regardless of whether an optional printer flex circuit is installed or not.

The optional user controls consist of three momentary push button elastometric contact switches. Pull up resistors are provided by the printer interface circuitry. R1, R2, and R3 help protect the input port by providing some current-limiting capability. C4, C5, and C6 debounce the switch contacts.

12.3 Calibration Verification for N-20P

CAUTION: Adhere to all testing instructions; failure to do so may damage the N-20P.

Overview

The N-20P is powered by alkaline batteries. The N-20P design includes built-in electrical insulation, no ground resistance or electromagnetic leakage testing is required. In addition, the N-20P required no calibration.

Required Tools and Equipment

The following tools and equipment are needed to perform test procedures.

- SRC-1 pulse oximetry tester
- Variable DC power supply; 1 amp supply, voltage range 0-6 VDC

Power-On Self Test (POST)

When an N-20P is switched on, a sequence of diagnostic tests are run that examine the instruments electronics and display functions. This power-up self-test consists of the following events:

Immediately after power is switched on, the instrument simultaneously:

- Displays the number "8" in all six Oxygen Saturation and Pulse Rate display field segments;
- Illuminates all 14 pulse rate amplitude indicator segments; and
- Illuminates the Pulse Search and Low Battery indicators.

During the next few seconds, the instrument:

- Switches off the display backlight;
- Displays three digits in the Oxygen Saturation display field representing the software version (for example, 123 is software version 1.2.3).
- Displays the printer status in the display fields; that is, either "Pr On" or "Pr OFF".

If a sensor is attached to the instrument, a zero ("0") appears in first position of the display fields, and the Pulse Search indicator flashes; if no sensor is attached to the instrument, horizontal dashes appear in all six Oxygen Saturation and Pulse Rate display fields, and the Pulse Search indicator flashes.

After approximately 1 minute:

- A short beep occurs and the instrument automatically switches off.

If at any time during the test sequence "Err" followed by a code number is displayed, make note of the error code and refer to error code descriptions in this manual.

Low Battery Test

The N-20P CPU monitors the battery voltage level and alerts the user via the Low Battery indicator when voltage is getting low. To test the proper function of the Low Battery indicator, connect the N-20P to an external, variable DC power supply.

Battery voltage levels below are accurate; however, slight variations may exist due to differences between batteries of different manufacturers. To that point, the N-20P operates normally at voltages above 4.0 VDC.

When the battery voltage drops below 4.5-3.8 VDC, the Low Battery indicator is lit, and the two lowest segments of the battery level meter are lit when the battery check button is pressed. When the voltage level drops below 4 VDC, the N-20P continues to display Oxygen Saturation and Pulse Rate values, but the printer no longer operates; otherwise, the N-20P operates normally.

Battery voltage levels below 4.0-3.4 VDC cause the Low Battery indicator to begin flashing. When the battery check button is pressed only the lowest segment of the Low Battery indicator will illuminate.

When the battery voltage level drops below 4.0-3.4 VDC, the N-20P turns itself off.

CAUTION: If a sensor is attached, remove it prior to running the following test.

1. Switch off the N-20P; open the battery door and remove the batteries.

2. Set the power supply's voltage to 5 VDC, and connect the supply to the battery clips of the N-20P – *ensure that polarity is correct.*

3. Switch on the N-20P; verify complete POST (the N-20P should operate normally).

4. Decrease the power supply voltage to 4.0 VDC or slightly below. Then, press the battery check button; within 15 seconds, the Low Battery indicator should illuminate and the lowest two segments of the battery level meter should illuminate; the sensor LEDs should remain lit; and, printer operation should cease.

5. Decrease the power supply voltage to 3.45 VDC or slightly below. Then, press the battery check button; within 15 seconds, the Low Battery indicator should begin to flash and only the lowest segment of the battery level meter should illuminate.

6. Decrease the power supply voltage to below 3.2 VDC. Within 15 seconds, the N-20P should turn itself off. Pressing the measure button should not turn the unit back on.

7. End Low Battery test.

Performance Testing

The N-20P will operate in conjunction with the NELLCOR pulse oximetry tester, model DRC-1, to test instrument performance. The SRC-1 plugs into the DB-9 sensor connector and uses the instrument's power supply and diagnostic software to test the display, the accuracy of the oximetry values and the operation of the instrument. Nellcor recommends routine performance testing at 1-year intervals. Refer to the SRC-1 operator's manual for details on performance testing with the SRC-1.

Other tests, which are outlined below, include the display backlight test, the low battery test, and the thermal printer test.

Backlight Test

The electroluminescent backlight illuminates the display in three sections: (1) the main section, ie., the Oxygen Saturation and Pulse Rate display fields, and the 14-segment pulse rate amplitude indicator; (2) the Low Battery indicator and (3) Pulse Search indicators each have their own backlight. Each backlight flashes once during POST.

The ambient light is located underneath a small circular window in the top right corner of the N-20P display. Under low light conditions, the main section backlight is switched on. If a Low Battery and Pulse Search indicator is lit, its backlight is also lit.

To test for proper operation of the display backlight, observe the N-20P in a darkened room. If any backlight section is not working correctly, contact Nellcor's Technical Services Department or Nellcor's local representative for assistance.

Printer Test

The SRC-1 can be used to test the operation of the N-20P printer and the printer's user-control buttons. When an SRC-1 is plugged into the DB-9 connector, the N20P does not respond to button presses during POST; however, it does acknowledge any button press with an immediate beep and the following play codes:

Button Press	Display
measure	gO
battery check	bAt
ON	On
ADV	Ad
D/D	dd
combinations	Err

1. Press the measure button: "gO" appears in the Oxygen Saturation display.

2. Press the battery-check button: "bAt" appears in the Oxygen Saturation display.

3. Press the printer ON~ button "On" appears in the Oxygen Saturation display.

A printer test pattern prints out; the following is an approximate example of the test pattern:

N-20P PRINT TEST
00-00-00 00:00
ABCDEFGHIJKLMNOP
QRSTUVWXYZp2%.*-.
0123456789:#',
()!<>?V≈√~
vvvvvvvv
= = = = = = = = =

Examine the test pattern to verify that all dots print with a uniform darkness. Overall printout darkness can be adjusted. If printout darkness is either irregular or dots are missing, contact Nellcor's Technical Services Department or Nellcor's local representative for assistance.

4. Press the printer ADV button: "Ad" appears in the Oxygen Saturation display. Paper advances one line for each button press.

5. Press the printer D/D button: "dd" appears in the Oxygen Saturation display.

6. End SRC-1 printer test

12.4 Troubleshooting

WARNING: Disassembly of the N-20P can expose service personnel to potentially hazardous voltages. For protection of service personnel and patients, the procedures must be performed as described in this section. Repair and testing must only be performed by qualified service personnel. Improper repair and/or adjustment may compromise patient safety or the accuracy of the instrument.

Required Equipment/Tools

- Screwdriver, Phillips
- Screwdriver, small flathead
- Pliers, long nose
- Soldering iron, low-power

N-20P Disassembly Procedure

Whenever repair or disassembly is required, always wear a ground strap connected to active ground. Before any disassembly or service procedure, switch instrument power off.

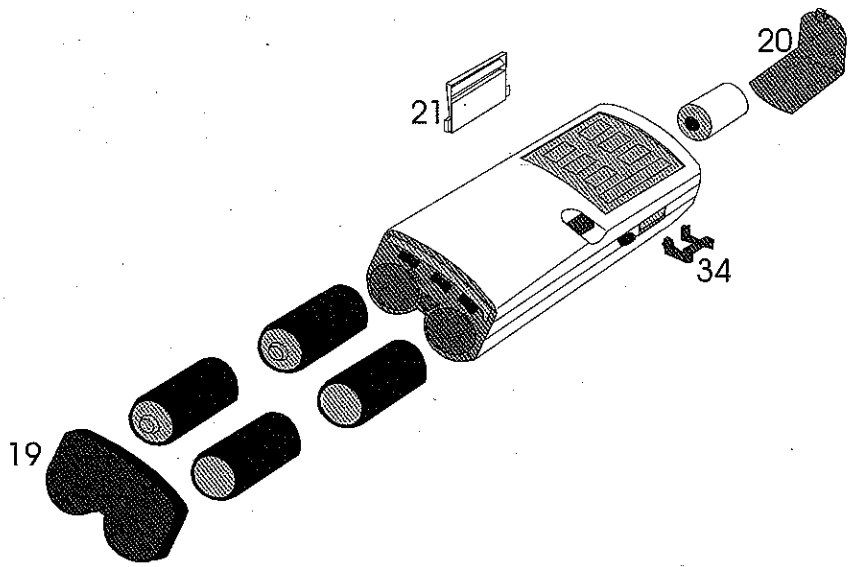


Figure 12.8 Sensor Lock, and Printer, Paper, and Battery Access Doors

1. Remove the battery door (19) and batteries.
2. Remove the sensor lock (34) by lightly pressing in on its ears and pulling out from the sensor shroud.
3. Remove the paper door (20) and paper roll, and the printer door (21).

Removing the Covers

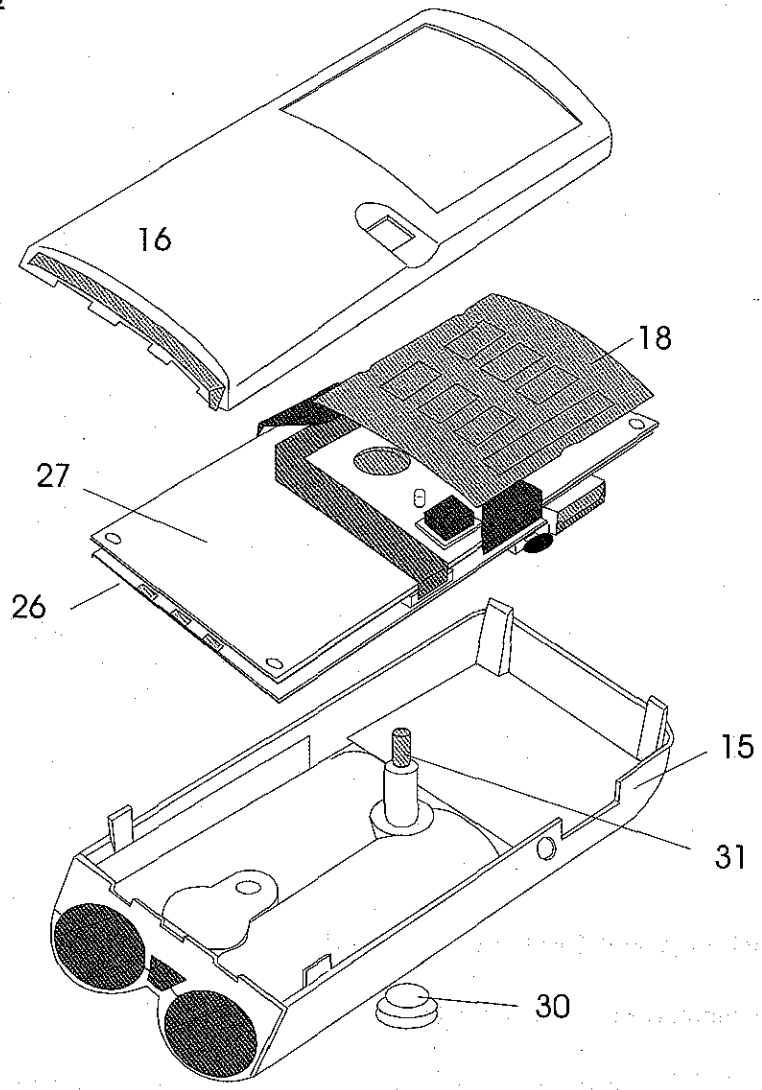


Figure 12.9 N-20P Covers with the PCB and Display Assembly

1. Remove screw cap (3), and loosen the captive screw (31) which secures the rear battery cover (15).

2. Separate the front cover (16) from the rear cover by wedging a thin flathead screw driver between the covers at the base of the instrument and slowly prying them apart.

> **NOTE**: The covers are hinged at the top end in a different way; do not attempt to separate the covers using this technique at the top of the instrument. Once the covers are separated at the bottom end, lift away the bottom end of the front cover first, allowing the tabs at the top end to act as a hinge.

Removing the PCBs and Display Assembly

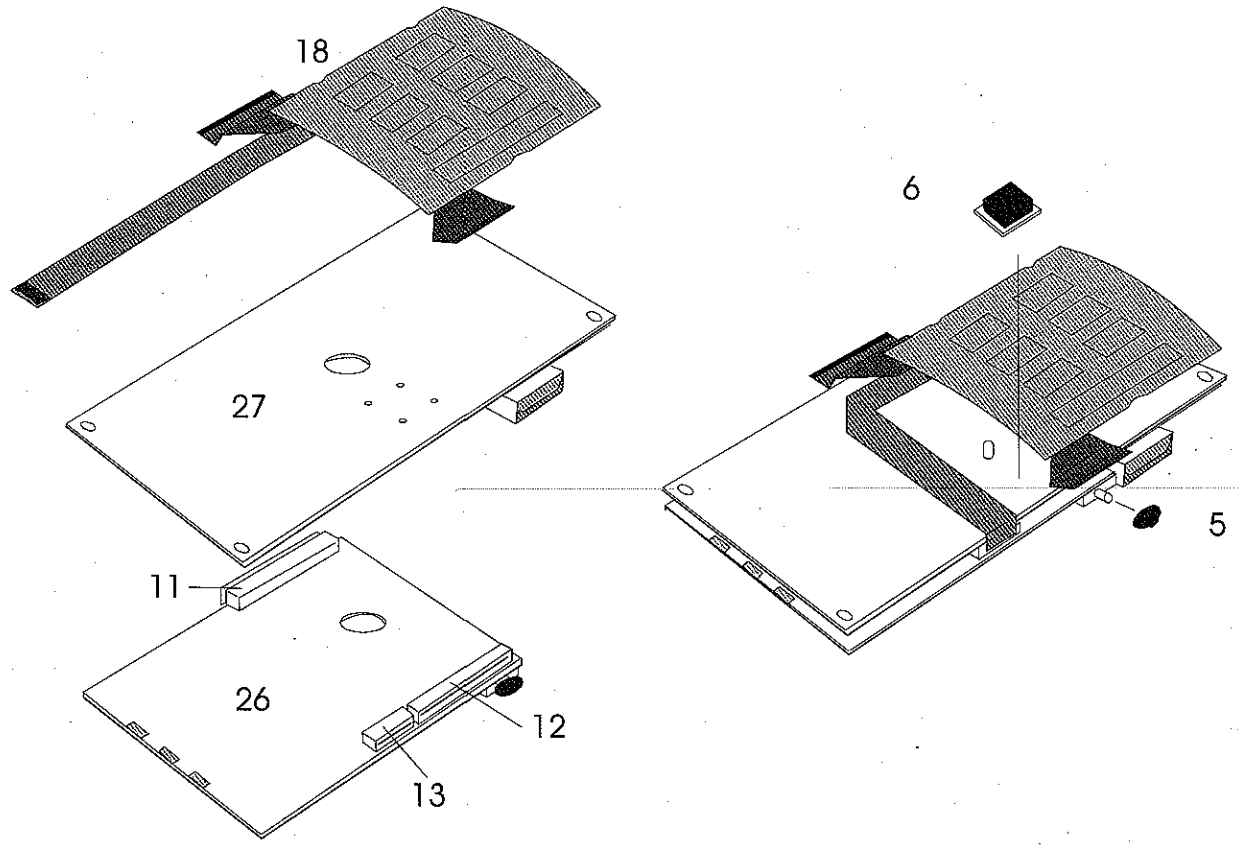


Figure 12.10 Main, Auxiliary, and Display PCB Assembly

1. Remove the measure button (6) from the main PCB.

2. Remove the entire PCB/Taliq display assembly from the rear battery cover by tilting opposite the battery check button (5).

3. Release connectors (11, 12, and 13) on the auxiliary PCB (26) and remove the three flex display circuits.

4. Separate the auxiliary PCB from the main PCB (27) by pulling the PCB headers apart at the base.

5. Remove the display assembly (18) from the main PCB by unsoldering the four tabs that are physically bent around the main PCB. These tabs are bent to ensure contact with the ground plane of the main PCB.

6. Using a long nose plier, remove the metal shroud by untwisting the four tabs (see Detail A and B).

N-20P Disassembly Procedure

1. Remove the paper door (20) and any printer paper by firmly grasping the paper roll, and pulling the roll outward from the printer.

2. See "Disassembly procedure for removal of covers, PCBs, and the display assembly".

Disassembling the Printer/Flex Circuit Assembly

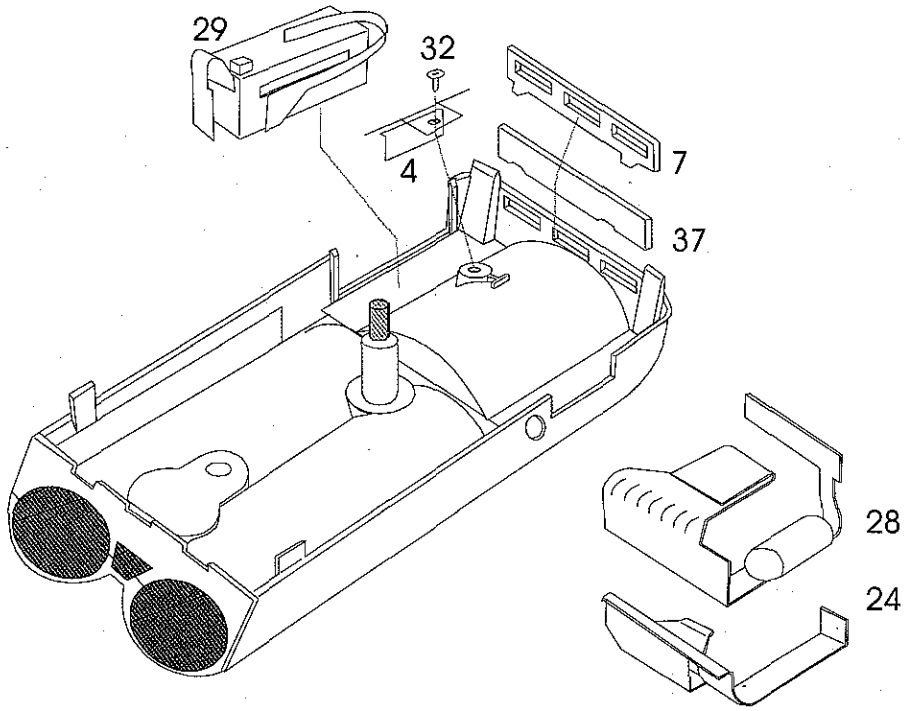


Figure 12.11 Printer and Flex Circuit installation

1. Remove the printer button stiffener (37).

2. Disconnect the two flex-circuit headers of the printer (29) from the connectors on the printer flex circuit (28) by slowly pulling outward from side to side at alternating ends of the connectors.

3. Remove the printer button strip (7) from the printer flex-circuit.

4. Remove the printer flex-circuit insulator (24).

5. Remove printer hold-down bracket (4) from the back cover by removing the Phillips screw (32).

6. Press the printer hold-down bracket into the back cover and remove the printer.

WARNING: Disassembly of the instrument exposes hazardous voltages. To avoid injury or instrument damage, disassembly or maintenance must be attempted only by qualified service personnel.

Troubleshooting Guide

This section discusses potential symptoms, possible causes, and actions for their resolution. Should this trouble-shooting guide fail to address the symptoms evident in a particular N-20P, please contact Nellcor Technical Services Department or a local Nellcor representative for assistance.

If the N-20P does not perform as expected:

- Check for proper sensor placement
- Depending on concentration, indocyanine green, methylene blue, and other intravascular dyes may affect the accuracy of a measurement.
- These instruments are calibrated to read oxygen saturation of functional arterial hemoglobin (saturation of hemoglobin functionally capable of transporting oxygen in the arteries), significant levels of dysfunctional hemoglobins such as carboxyhemoglobin or methemoglobin may affect the accuracy of a measurement.

If the electronics and/or display functions require testing, refer to "Test and Calibration" in this manual.

SYMPTOM 1: No response to measure button.

CAUSE 1: Battery access door may not be properly latched.
ACTION 1: Check access door and ensure it is properly latched.

CAUSE 2: Batteries may be discharged.
ACTION 2: Exchange them for a new set.

CAUSE 3: Batteries may be incorrectly installed.
ACTION 3: Ensure that batteries are oriented according to the polarity indicator.

CAUSE 4: Batteries may not be making proper electrical contact.
ACTION 4: Inspect contacts for deformity; clean contacts to remove oxidation.

CAUSE 5: Fuse F1 on the auxiliary PCB may be open.
ACTION 5: See "Fuse Replacement"

CAUSE 6: Dust may have accumulated under measure button causing loss of electrical contact.
ACTION 6: Clean contact points under measure button (see "Disassembly Procedure").

SYMPTOM 2: Pulse Search indicator appears for more than 5-10 seconds.

CAUSE 1: Sensor may be improperly positioned.
ACTION 1: Ensure the sensor is correctly applied (see sensor directions for use).

CAUSE 2: Incorrect sensor may be in use.
ACTION 2: See sensor directions for use to ensure that the patient's weight and sensor application are correct. Test the sensor on another person to verify proper operation.

CAUSE 3: Perfusion may be too low.
ACTION 3: Check patient status. Test the instrument on someone else, or try another type of sensor. The N-20P will not make a measurement if perfusion is inadequate.

CAUSE 4: Foreign material on the sensor LEDs or photodetector may be affecting performance.
ACTION 4: Clean the test area and ensure that nothing blocks the sensor site.

CAUSE 5: Patient motion may be interfering with the instrument's ability to find a pulse pattern.
CAUSE 6: Environmental motion may be interfering with the instrument's ability to track a pulse.
CAUSE 7: The sensor may be too tight, there may be excessive illumination (e.g., a surgical or bilirubin lamp or direct sunlight), or the sensor may be placed on an extremity with a blood pressure cuff, arterial catheter, or intravascular line.
ACTION 5-7: If possible, ask the patient to remain still. Verify that the sensor is securely applied and replace it if necessary, move it to a new site, or use a sensor that tolerates patient movement, such as an appropriate adhesive sensor.

CAUSE 8: The DB-9 sensor connector on the N-20P may be broken.
ACTION 8: Replace the DB-9 connector.

SYMPTOM 3: Pulse Search indicator appears after successful measurements have been made.

CAUSE 1: Patient perfusion may be too low.
ACTION 1: Check patient status. Test the instrument on someone else, or try another type of sensor. The N-20P will not make a measurement if perfusion is inadequate.

CAUSE 2: Patient motion may be interfering with the instrument's ability to find a pulse pattern.
CAUSE 3: Environmental motion may be interfering with the instrument's ability to track a pulse. The sensor may be too tight, there may be excessive illumination (e.g., a surgical or bilirubin lamp or direct sunlight), or the sensor may be placed on an extremity with a blood pressure cuff, arterial catheter, or intravascular line.
ACTION 2,3: If possible, ask the patient to remain still. Verify that the sensor is securely applied and replace it if necessary, move it to a new site, or use a sensor that tolerates patient movement, such as an appropriate adhesive sensor.

SYMPTOM 4: Dashes (- - -) appear in the display.

CAUSE 1: The sensor is not connected to the instrument.
ACTION 1: Check all sensor connections; try substituting another sensor. Check all extensions cables. If an extension cable is in use, remove it and plug the sensor directly into the instrument.

SYMPTOM 5: Pr Err is displayed during the POST.

CAUSE 1: The printer is not operational, but the N-20P continues to obtain patient measurements.
ACTION 1: Check to see if the paper is jammed. Examine the print head and ensure that it has returned to the home position.

SYMPTOM 6: Err followed by a number appears on the display.

CAUSE 1: See "Error Codes" in this manual.
ACTION 1: Record the number that is displayed.

SYMPTOM 7: Time or date is incorrect.

CAUSE 1: The real-time clock battery may be exhausted.
ACTION 1: Replace the RTC battery. Reset the time and date.

SYMPTOM 8: Printer fails to operate.

CAUSE 1: Fuse F2 on the auxiliary PCB may be open.
ACTION 1: See "Replacing Fuses" in this manual.

SYMPTOM 9: Printer paper advances but instrument does not print.

CAUSE 1: The thermal paper may be improperly loaded; characters can be printed on only one side of the thermal paper roll.
ACTION 1: Ensure that the thermal paper is properly loaded; if needed, remove the roll of printer paper and reload the printer paper.

SYMPTOM 10: Paper mechanism jams.

NOTE: If a printer paper jam is detected during POST, Pr Err may appear on the display.

ACTION 1: Switch off the N-20P. Then check to see if the print head is at the home position, if so, attempt to pull the paper out by pulling gently – do not force it.

If the print head is not a the home position, and the paper cannot be easily pulled out from the printer, then the printer may need to be disassembled to remove the paper jam (see "Disassembly Procedure" and "Loading/ Clearing Printer Paper").

12.5 Parts List

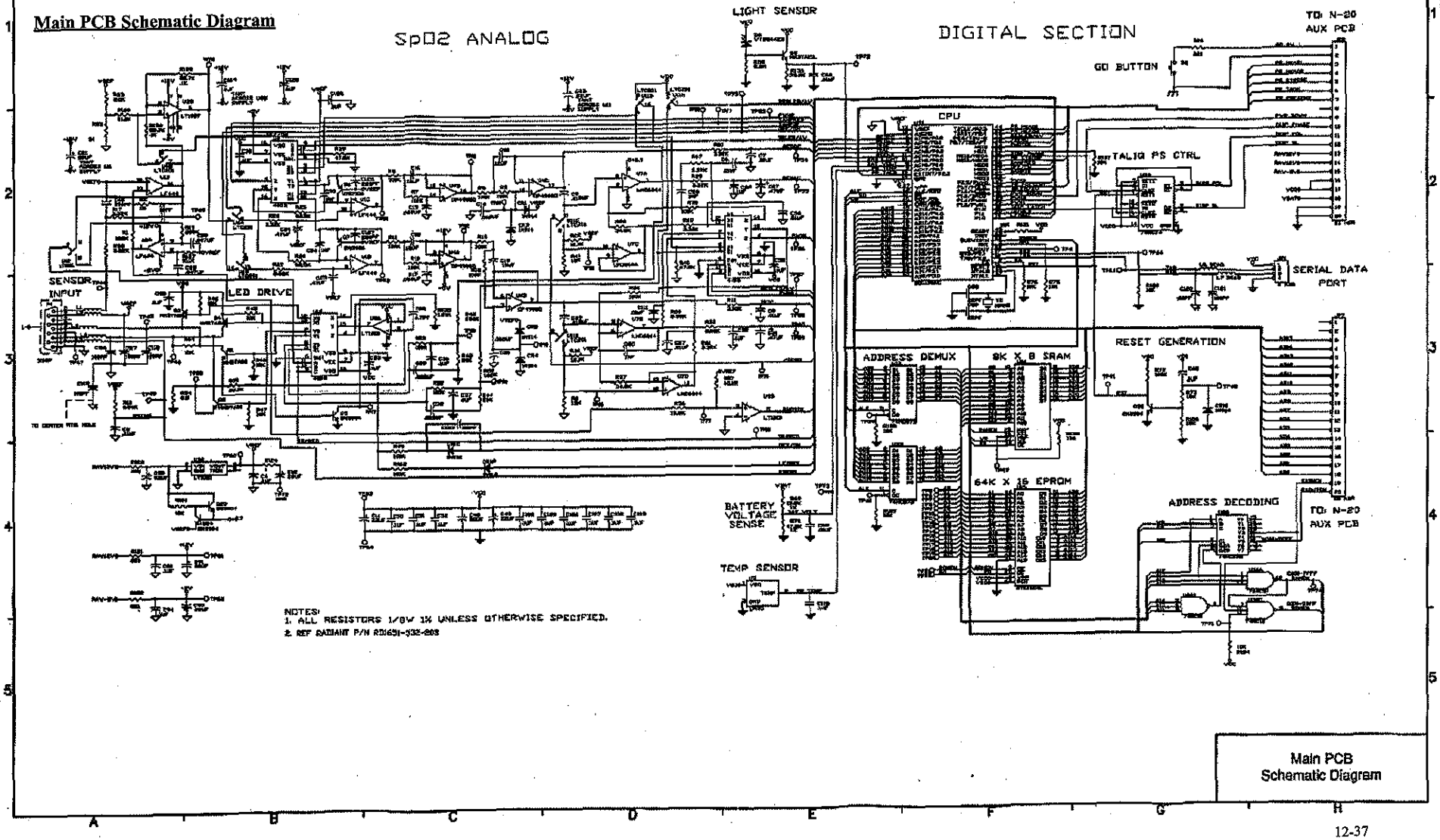
N-20P Spare Parts. To order replacement parts, contact Nellcor Puritan Bennett's Technical Service Department at 1-800-NELLCOR and order by part number.

Item	Designator	Description	P/N
1.	SW1	Battery switch (auxiliary PCB)	630106
2.	BTi	Battery holder (auxiliary PCB)	901582
3.	BTi	Battery, lithium (auxiliary PCB)	640112
4.		Bracket, printer, hold-down	203133
5.		Button, battery-check	023301
6.	S2	Button, measure	022948
7.		Buttons, printer, strip	022947
8.	L1, L2	Coil, 120 H SMT (auxiliary PCB)	691238
9.		Connector shield, DB-9	463103
10.		Connector, DB-9	463103
11.	JP17, JP18	Connector, pin header 1Ox2, low profile (auxiliary PCB)	491244
12.	JP5	Connector, ZIF, flex, 7-pin (auxiliary PCB)	491242
13.	JP9	Connector, ZIF, flex, 22-pin (auxiliary PCB)	491250
14.	JP2,3	Connector, ZIF, flex, 32-pin (auxiliary PCB)	491243
15.		Cover, battery, rear (non-printer model)	022929
16.		Cover, front, with gasket assembly	022921
17.	D8	Diode, photo, 8440 (main PCB)	591017
18.		Display, Taliq, analog shield assembly	024466
19.		Door, battery	022924
20.		Door, paper	022938
21.		Door, printer	026338
22.	F2	Fuse, micro, 1 amp (auxiliary PCB)	691236
23.	F1	Fuse, micro, 1.5 amp (auxiliary PCB)	691239
24.		Insulator, printer	026139
25.		Nut, keps, SS, 4-40	851101
26.		PCB, auxiliary	024472
27.		PCB-B, main	024468
28.		Printer flex circuit	024464
29.		Printer	024462
30.		Screw cap	023451
31.		Screw, captive	891324
32.		Screw, Philips, 4-40 X 1/4	801025

Item	Designator	Description	P/N
33.		Screw, plastite	871031
34.		Sensor lock	022943
35.		Sensor shroud	022944
36.		Spacer	023452
37.		Stiffener, printer button	023131
38.		Tap, foam (.88" x .38")	023300
39.	BZ1	Transducer, audio, piezo ceramic	691230

12.6 Schematics

Main PCB Schematic Diagram



12.6 Schematics

Auxiliary PCB Schematic Diagram